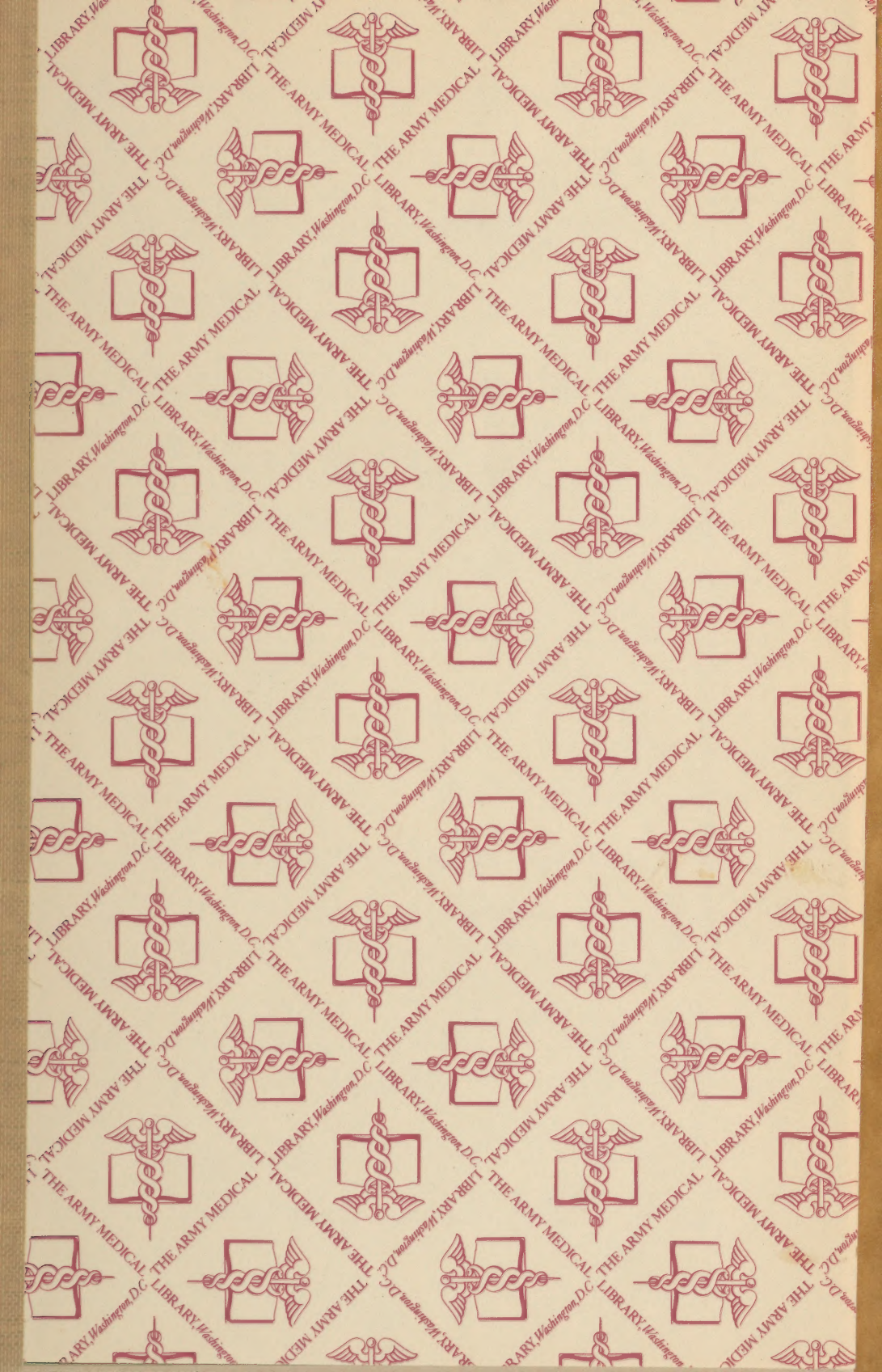
MINNESOTA DEPT. OF HEALTH

OPERATION AND MAINTENANCE OF MUNICIPAL AND LARGER INSTITUTIONAL SEWAGE AND WASTE TREATMENT PLANTS IN MINNESOTA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Operation and Maintenance of Municipal and Larger Institutional Sewage and Waste Treatment Plants in Minnesota

MINNESOTA DEPARTMENT OF HEALTH

Section of Environmental Sanitation
Division of Water Pollution Control

1947

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Contents

The Operation and Maintenance of Municipal and Larger Institutional Sewage and Waste Treatment Plants in Minnesota

Introduction

This information has been prepared as an aid to municipal officials who are responsible for the operation of sewage treatment plants in Minnesota, and as a guide to plant operators in the care of their plants. Local conditions may alter somewhat the operating procedure, but, in general, this information will be found applicable to the various treatment units described.

A sewage treatment plant represents the investment of a considerable sum of money expended primarily for the purpose of preventing pollution of the waters of the State. The degree of success attained in the operation of such a plant is to a large extent a direct result of, and in proportion to, the intelligence and effort expended.

The State Water Pollution Control Act, Laws of 1945, Chapter 395, defines pollution and waters of the State as follows:

> " 'Pollution' means the contamination of any waters of the state so as to create a nuisance or render such waters unclean, or noxious, or impure so as to be actually or potentially harmful or detrimental or injurious to public health, safety or welfare, to domestic, commercial, industrial or recreational use, or to livestock, wild animals, birds, fish, or other aquatic life."

> " 'Waters of the state' means all streams and lakes, including all rivers and lakes bordering on the state, marshes, watercourses, state, county, town or judicial drainage systems and other bodies of water, natural or artificial, public or private, of such character that the pollution thereof may create a nuisance or be either actually or potentially harmful or detrimental to the public health, safety or welfare, or to domestic, commercial, industrial or recreational use, or to livestock, wild animals, birds, fish, or other aquatic life."

Pollution of the waters of the State resulting from the discharge of domestic sewage or industrial waste by a municipal sewer system has been held to be the responsibility of the municipality (Huber vs. City of Blue Earth, Minnesota Supreme Court, November 1942).

In addition to having a clear idea of the operating procedure, it is essential that officials understand the limitations of the processes used in the plants under their control. Plate I shows the reduction in strength which may be expected to be obtained by passing sewage through various treatment plants under satisfactory operating conditions as measured by the five-day biochemical oxygen demand test. By definition, the biochemical oxygen demand of a polluted water is the amount of oxygen, expressed in the usual concentration

COMPARATIVE REDUCTION IN STRENGTH OF SEWAGE ACCOMPLISHED BY VARIOUS TYPES OF TREATMENT UNITS

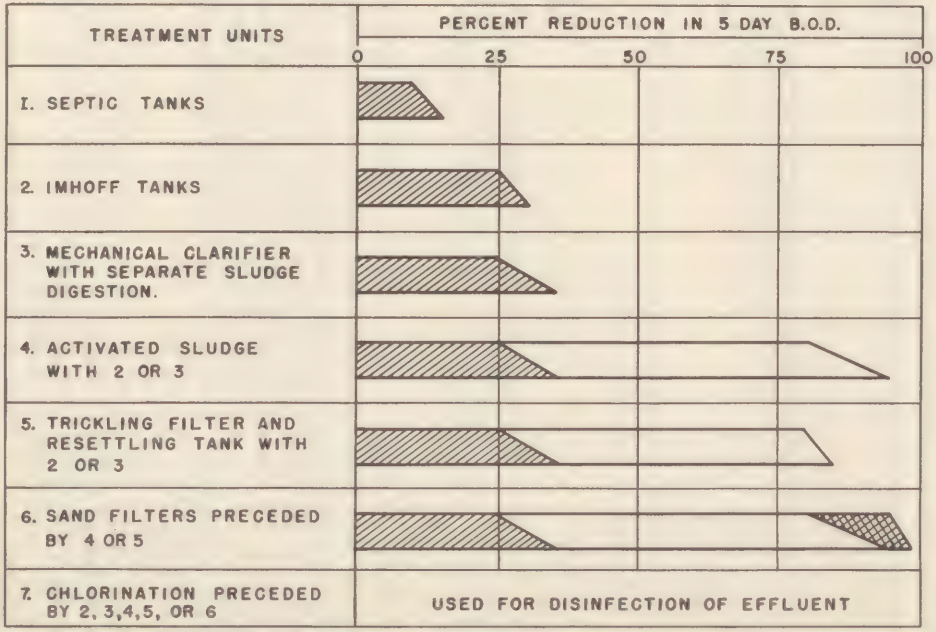


PLATE-I

units, required to bring that water into a state of final oxygen equilibrium in the presence of oxygen, bacteria, and other microscopic life, and the residual organic products.* This test is frequently used to express the relative strength of polluted waters.

Treatment works or disposal systems are designed primarily for the treatment or handling of sewage or industrial wastes. Storm water and roof drainage should be excluded as far as possible. Data on the design and capacity of plants are contained in the report on the examination of plans made by the State Department of Health, Division of Water Pollution Control, and forwarded to the municipality with the approved plans.

The issuance of permits by municipalities for admission of industrial wastes to the sewerage system should be given thorough consideration. The industrial wastes that are most frequently encountered in Minnesota are those from creameries, milk plants, locker plants, rendering works, canneries, sugar refineries, packing plants and paper mills. The strength of some of these wastes, as compared with domestic sewage, is shown in Plate II.

Excessive quantities of industrial wastes may overload the pipe-collection system or the sewage-treatment plant. The strength or chemical characteristics of the waste may cause deposits to occur in the pipe line and develop offensive odors, or may so affect the ordinary processes in the treatment plant as to render them ineffective. Where there is any question as to the effect of any particular industrial waste, it is desirable to obtain competent advice before any permit for a connection is issued.

To assist the operator in obtaining proper operation and maintenance the following data should be available at all plants:

1. Complete construction plans of the plant as it was built.

2. Complete description of each piece of equipment with a list of spare parts and manufacturers instructions for operation and maintenance.

3. Maintenance schedule for each piece of equipment showing the time and the person responsible for necessary lubrication, adjustments and inspections.

4. Daily operating report.

Sufficient time should be spent at the plant to permit the operator to keep all units in operating condition, do necessary maintenance and repair work, make necessary tests and keep proper records. Good housekeeping is essential both inside and outside the plant. Where difficulty is experienced in financing the operation by general funds, it is suggested that consideration be given to the use of sewer service charges as provided for (Chapter 211, Laws of 1935, and Chapter 57, Laws of 1937).

*Public Health Bulletin No. 173, the Oxygen Demand of Polluted Waters.

COMPARATIVE STRENGTHS OF TYPICAL INDUSTRIAL WASTES

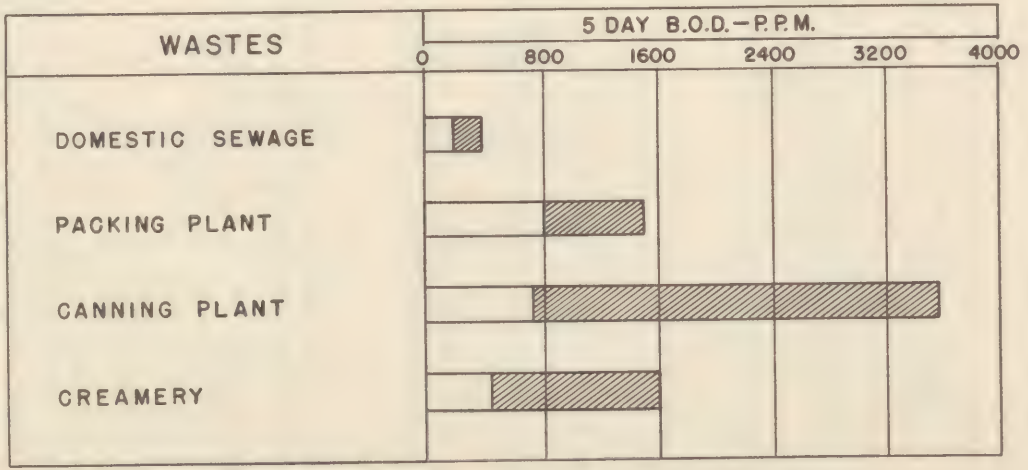


PLATE - II

Section I GRIT CHAMBERS

1. Description and Purpose

A grit chamber consists of a small chamber, usually long and rectangular, in which the velocity of the sewage is reduced to such an extent (approximately one foot a second) that heavy inorganic suspended matter such as coal, grit, sand and gravel, etc., may be settled out. The removal of this material tends to prevent excessive wear or clogging of pumps and equipment. Trouble caused by accumulation of this material in subsequent units of the plant is also reduced.

2. Operation

A. In small plants grit is removed manually at predetermined intervals while larger plants have mechanical grit removal equipment which operates intermittently or continuously depending upon individual plant conditions.

B. Accumulation of grit should be removed before efficiency of the operation of the unit is reduced.

C. Disposal of the collected material should be made in one of the following manners:

1. Bury, if manually removed, covering by at least six inches of earth, either by ploughing under the soil or shallow trenching. In winter it may be placed in trenches, treated with chloride of lime or other disinfectant and covered with earth in the spring as early as possible.
2. Use as fill mechanically removed and washed grit.

Section II COARSE SCREENS AND CUTTING SCREENS

3. Description and Purpose

Coarse screens or cutting screens are provided to prevent large objects such as rags and sticks, etc., from clogging or damaging pumps, piping, small channels or other equipment. Bar screens consist of a grid of steel bars spaced approximately two to two and one half inches apart, center to center, placed in the influent channel of the plant inclined at an angle in the direction of flow of the incoming sewage. Cutting screens have revolving drums or cylinders on which are located cutting blades. These screens (electrically driven) are placed in the influent channel and eliminate the necessity of removing screenings by cutting all solids so they can pass through the screens with the sewage.

4. Operation

Screenings, unless properly disposed of, are frequently a serious source of nuisance at a treatment plant because they decompose readily, giving off obnoxious odors. They will also encourage the breeding of rats and flies unless properly cared for.

A. If bar screens are used remove the screenings daily, or oftener if necessary, to prevent clogging of the screen and consequent backing up of sewage in the outfall sewer.

B. Prompt disposal of the screenings should be made in one of the following manners:

1. Bury, covering by at least six inches of earth either by ploughing under the soil or shallow trenching. In the winter, they may be placed in trenches, treated with chloride of lime or other disinfectant and covered with earth in the spring as early as possible.

2. Incinerate after draining.

C. Clean the screen chamber, removing all accumulated sludge and grease, at least once a week.

D. Small quantities of screenings can be conveniently handled in tightly covered galvanized garbage cans.

Section III MEASURING DEVICES

5. Description and Purpose

Weirs, Parshall flumes, Venturi tubes and flow meters are most frequently used to measure flow of sewage. These devices are usually installed either in the influent channel or effluent channel of the plant. They may also be installed to determine the quantity of sewage recirculated through the plant units. To permit intelligent operation of a sewage treatment plant it is essential that some method of determining flow through the plant be available.

Flow, if necessary, may also be determined by timing the operation of pumps and calculating their output or by counting the dosing cycles of the dosing apparatus if such equipment is used in the plant.

6. Operation

A. Measuring devices must be kept clean of deposits which may accumulate.

B. Where recorders are used charts must be changed regularly and the recording device must be properly maintained.

Section IV FINE SCREENS

7. Description and Purpose

A fine screen (a continuously revolving drum covered with a fine-mesh screen) removes a part of the suspended solids, as well as coarse material, thereby relieving the load on subsequent treatment units.

8. Operation

A. Fine screens are usually cleaned continuously and mechanically either by water, air or revolving brushes. All moving parts should be oiled or greased sufficiently to keep them in proper working condition.

B. The solids retained by the screen may be disposed of in one of the following ways:

1. Convey the solids to the digester or chemical mixing vats and treat with other solids.
2. Dewater and burn the solids.
3. Bury, covering by at least six inches of earth, either by ploughing under the soil or shallow trenching. In the winter they may be placed in trenches, treated with chloride of lime or other disinfectant and covered with earth in the spring as early as possible.

Section V IMHOFF TANKS

9. Description and Purpose

Imhoff tanks, sometimes known as two-story settling tanks, have an upper, or flowing through, compartment for primary settling of the sewage to remove the settleable suspended solids. A lower or digestion compartment is provided to liquefy, gasify, and digest the settleable solids. (See Plate III)

A trapped slot between these compartments enables the solids which are settled out of the sewage in the upper chamber to pass into the lower or sludge-digestion compartment. This trapped slot also prevents the gases produced by decomposition in the digestion compartment, together with gas-laden particles of sludge, from getting into the settling compartment and from coming in contact with the settling sewage. These gases and gas-laden particles are deflected by the sloping bottom of the sedimentation compartment and rise in the scum chamber, or gas vent, where the gases escape and a large part of the previously gas-laden material settles again. In a tank which works properly, the gases given off should be inoffensive with a slightly tarry or gassy odor.

10. Operation

A. SEDIMENTATION COMPARTMENT

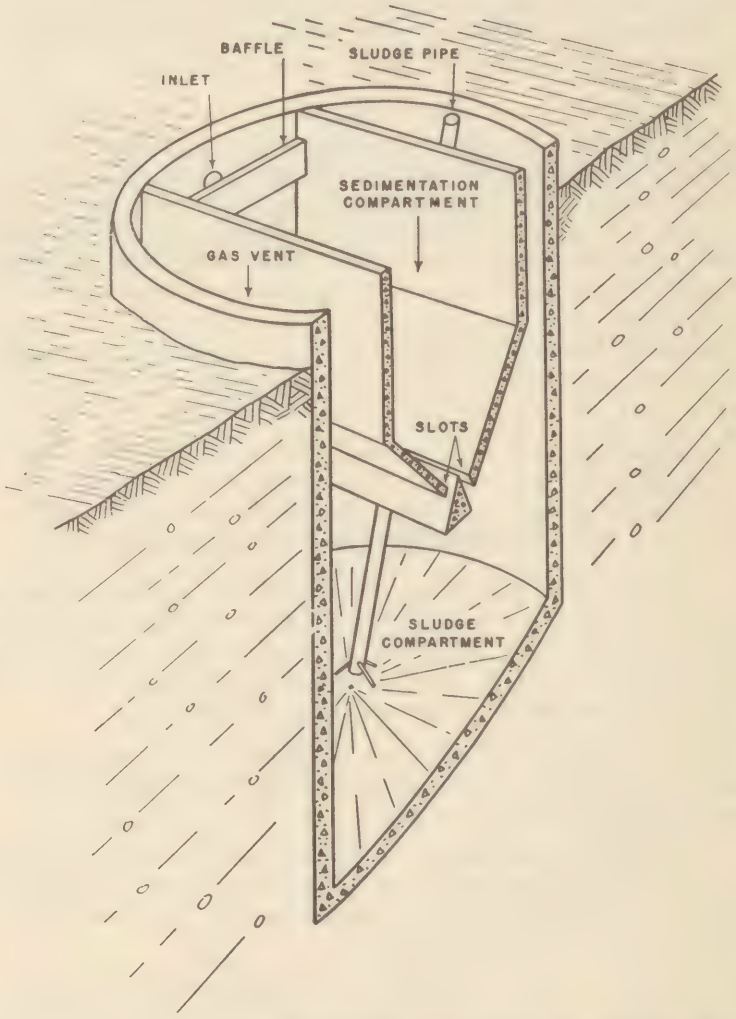
1. Grease and scum in the sedimentation compartment should be removed daily. This is best accomplished by the use of a dish-shaped perforated skimmer (see Plate IV). Such grease and scum should be promptly disposed of by burying or burning. Where objectionable conditions are not likely to develop, the grease and scum may be placed in the gas vents.

2. The sides and slopes of the sedimentation compartment should be carefully scraped with a rubber squeegee (see Plate IV), and all solids pushed down through the slots at least every week.

3. The slot in the bottom of the sedimentation compartment must be kept open and free from obstruction of any kind. Every other day the slot should be cleaned by the use of a chain drag (see Plate IV), taking care to traverse the entire length of the slot.

4. Failure to follow carefully the foregoing operating procedure will usually result in an effluent of inferior quality and, where a trickling filter is used, there will be deposits and accumulation of solid material on or in such filter, due to grease, scum or sludge being carried through the tank.

5. Where the design of the tank will permit, the direction of flow through the sedimentation compartment should be reversed at least once a month, in order to distribute the solids uniformly in the digestion or sludge compartment.



SECTION OF CIRCULAR SETTLING TANK, TWO STORY OR IMHOFF TYPE
PLATE III

B. GAS VENTS OR SCUM COMPARTMENT

The scum in the gas vent should be thoroughly broken up at least once a week so that the gases from the digestion or sludge compartment will escape easily. This may be accomplished by one of the following means:

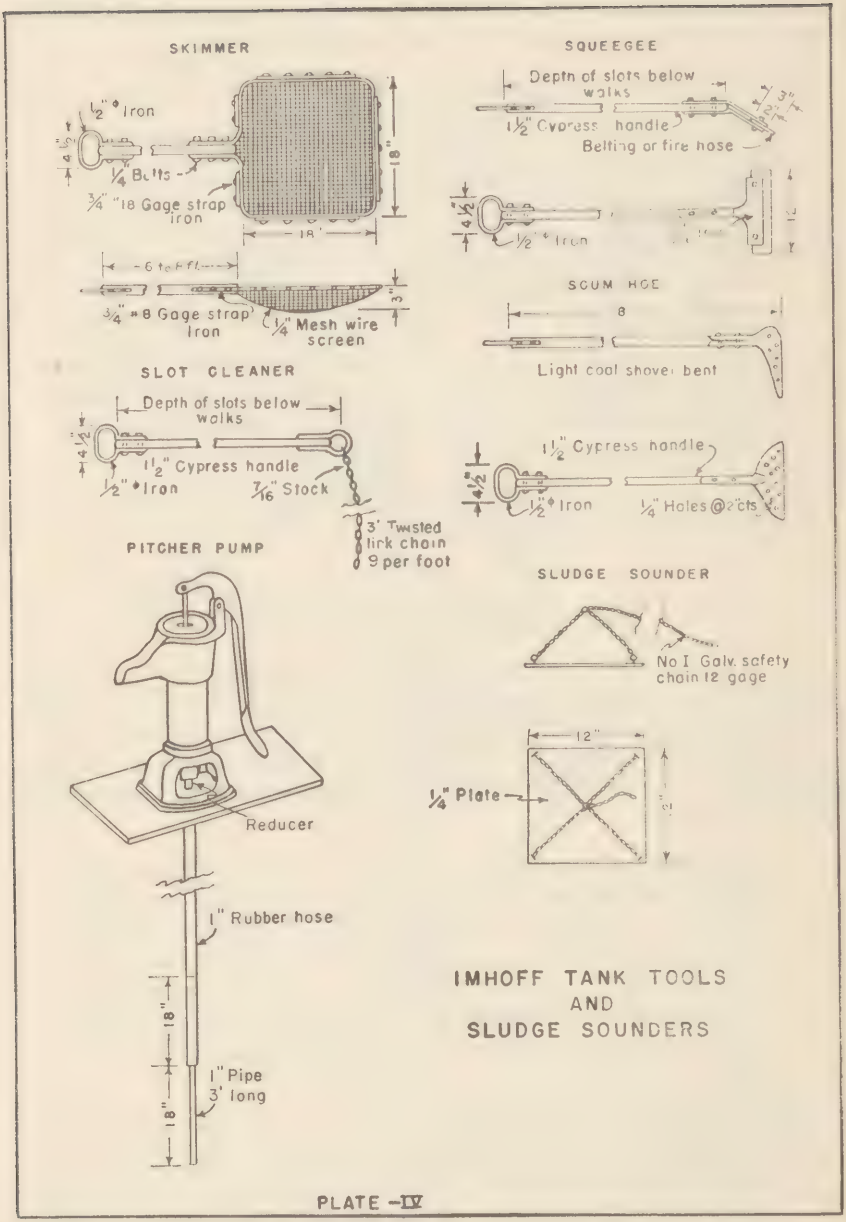
1. Break up the scum with a hoe, rake, or other suitable tool.
2. Hose the scum in the gas vents with water under pressure.
3. Keep the scum in the gas vents saturated with sewage from the sedimentation compartment, or preferably with liquor from the digestion compartment, by using a small pump or air-lift device.
4. Punch holes through the scum at two-foot intervals with a wooden pole, three inches in diameter and eight to ten feet long.
5. Treatment of the scum in the gas vents daily with hydrated lime at a rate of about 10 pounds per 1000 population has been helpful in controlling excessive scum formation and to aid in maintaining the pH value of the digesting sludge at from 7.2 to 7.6.
6. The scum may be removed and dried in a sludge drying bed if its depth approaches two or three feet.

C. SLUDGE COMPARTMENT

1. The height of the sludge in the sludge compartment should be determined at the inlet and the outlet ends of the tank at least once a month. For this purpose, it is most desirable and satisfactory to use a pump. It is not recommended that the plate or disc method be used except for the final settling tank. Any of the following are suitable methods for measuring the depth of the sludge.

a. A pitcher pump provided with a rubber suction hose, weighted on the end and the length marked on the hose at intervals of two feet (see Plate IV), measuring from the weighted end toward the pump. The hose is gradually lowered through the slot in the sedimentation compartment, meanwhile pumping constantly, and the length of immersed hose when sludge first comes through the pump is determined. When sludge is encountered, the pump will usually "choke" before the sludge appears.

b. A pitcher pump may also be used with a rubber suction hose, weighted on the end by a four-foot length of steel pipe as an integral part of the pump suction line. This suction hose may be graduated and marked as above and the determination of sludge made in the same manner except that the hose is lowered through the gas vent instead of the sedimentation compartment slot.



IMHOFF TANK TOOLS
AND
SLUDGE SOUNDERS

PLATE -IV

c. The sludge depth may also be determined by the use of an iron plate or weighted wooden block, about 12 to 18 inches square, attached to a wire or chain (see Plate IV) and lowered through the gas vent. The plate or block will stop when the sludge is reached and the distance from the surface to the sludge level is determined by the graduated wire or chain by which the device is lowered.

2. Sludge should be removed in small amounts at frequent intervals (1-2 months during summer) rather than in large amounts at longer intervals and should be removed whenever the sludge depth approaches within 18 inches of the slot in the sedimentation compartment. It should be removed at a low regular rate to avoid the formation of channels through the sludge in the compartment and the consequent withdrawal of partially digested sludge or liquid above the sludge.

3. If the sludge does not flow readily, it may be started by one of several methods:

a. Agitate with water under pressure through perforated water pipes in the bottom of the sludge compartment, if such pipes are available.

b. Apply water pressure through hose immersed into the sludge compartment or through the sludge riser pipe. (Because of the possibility of contaminating the water supply used as outlined in paragraph a. and this paragraph, there should be no direct connection made with any source of water used for domestic purposes.)

c. Agitate around sludge inlet with long rods through the sludge riser pipe.

4. Avoid the withdrawal of all the sludge from the tank. Leave sufficient digesting or "seed" sludge to prevent the difficulties incidental to starting a new or completely cleaned tank. Usually not over half the depth of sludge in the tank should be removed at any one time.

5. After they have been used, the sludge pipes should be flushed out and refilled with water or sewage to prevent the sludge from hardening and clogging them.

11. "Foaming" in Imhoff Tanks

"Foaming" is a term used to describe the condition which develops sometimes in Imhoff tanks, whereby gas, froth and scum rise in the scum compartment or gas vent and carry over the wall into the sedimentation compartment. Besides being unsightly and disagreeable, this foaming seriously interferes with the efficiency of the plant. Dark scum and solid material may

be carried into the sedimentation compartment and be discharged in the tank effluent. This will cause an unsatisfactory tank effluent and an abnormal load on subsequent treatment units.

There are a number of possible causes for "foaming" such as industrial wastes like milk or cannery wastes, "mash" or "wine" wastes, drawing out too much sludge at one time, or increased temperature in the sludge compartment. Foaming is frequently associated with an "acid" condition of the sludge and in such cases may be minimized or corrected by treatment to counteract the acidity.

When foaming persists, it is advisable to seek the advice of an experienced sanitary engineer.

Following are some simple treatments which may, under certain conditions, remedy or improve the condition:

A. Draw a quantity of sludge.

B. Hose the gas vent area with water under pressure.

C. Cut the tank out of service if possible and allow it to rest.

D. Paddle the foam with a long-handled hoe.

E. Add hydrated lime through the gas vents at daily intervals.

F. Treat the raw sewage with chlorine at rates of 20 to 50 pounds per million gallons.

Section VI PRIMARY SETTLING TANKS

12. Description and Purpose

Primary settling tanks are either rectangular or circular in shape usually having a relatively shallow liquid depth of six to eight feet. They may be constructed with plain hopper bottoms or be equipped with mechanisms for the collection of sludge. They are designed to remove a large part of the suspended solids by settling without anaerobic or septic decomposition taking place within the tank.

13. Operation

A. The settled solids or sludge should be either continuously removed to the sludge-digestion tanks by mechanical equipment, or should be completely removed at least once a day to the sludge-digestion tanks from the settling tanks which are not equipped with a continuous-removal equipment.

B. Septic action in the plain settling tanks as evidenced by "gassing" or an appreciable increase of the settleable solids in the settling tank effluent should be prevented by prompt and regular removal of sludge to the sludge-digestion tanks.

C. Grease and scum should be removed daily, using a perforated skimmer (see Plate IV), and the tanks should be maintained in a clean condition at all times.

Section VII SEPARATE SLUDGE-DIGESTION TANKS

14. Description and Purpose

Separate sludge digesters consist of large tanks with fixed or floating covers, heated or unheated, used singly or as primary and secondary units. These tanks are used to decompose, liquefy, or gasify solids transferred to them from plain settling tanks and to produce an innocuous material which can be disposed of readily.

15. Operation

A. The contents of the tank should be stirred or agitated at frequent intervals by recirculation or other means to assure proper "seeding" of the fresh solids and to afford rapid and efficient digestion. Such stirring also lessens the possibility of "foaming" difficulties and excessive scum formation.

B. Where heating coils or other means of heating the contents are available, the temperature should be maintained at 80° to 90° F.

C. The amount of raw sludge added daily should not be over one-twentieth of the amount of "ripe" sludge in the tank, on the basis of the dry solid content.

D. When unusual conditions, such as "foaming," "acid," sludge, etc., develop and the operator is not experienced in handling such conditions, an experienced sanitary engineer should be called in and his recommendations followed.

E. Care must be used in removing digested sludge to avoid the removal of such a large amount that the ratio of "ripe" sludge to raw sludge added drops below twenty to one.

F. The reaction of the sludge should be maintained at a pH value of 7.2 to 7.6. The addition of lime or other alkaline reagents to the sludge will increase the pH value of the sludge. Satisfactory results are occasionally obtained with slightly lower values.

Section VIII SLUDGE CONDITIONING EQUIPMENT

16. Description and Purpose

This equipment consists of a small mixing tank and mixing device. Raw sludge is pumped to the mixing tank and certain chemical coagulants are added and mixed with the sludge to facilitate separation of the water when the sludge is drawn to sludge beds. In larger plants chemically conditioned sludge is dewatered with a rotary drum type vacuum filter and then incinerated or disposed of in the same manner as sludge from sludge drying beds.

17. Operation

A. Sludge should be treated with chemicals and placed on drying beds promptly after it is pumped from the settling tanks.

B. The quantities and proportions of chemical must be determined by practical experience as well as the necessary length of time of mixing required.

C. Chemicals for sterilizing sludge may be added to the sludge at the same time as the coagulants.

Section IX DOSING APPARATUS

18. Description and Purpose

Dosing apparatus usually consists of a dosing tank and siphon and provides for periodic and uniform distribution of the sewage on low rate or conventional type filters or on sand filters.

19. Operation

A. The mechanical equipment should be kept in perfect working order. Moving parts should be regularly oiled or greased.

B. Pipes and air lines should be kept open and free from obstructions and accumulations of any sort.

C. Any mechanical breakdown should be repaired immediately.

D. Where there are two units or where it is possible to cut out a unit without seriously interfering with subsequent treatment, a complete cleaning of the dosing tank should be made weekly, removing all grit and sludge deposits and all growths and deposits on pipes and walls. This is necessary in order to prevent clogging of the nozzles in a trickling filter unit. In the event that it is not feasible to cut out a unit, the walls and pipes should be cleaned as carefully as possible by means of an inverted scraper, taking care that solid material does not enter the dosing tank outlet.

Section X TRICKLING FILTERS

20. Description and Purpose

Trickling filters usually consist of concrete structures either rectangular or circular in shape containing six to eight feet of filter material of selected size and quality. Sewage may be applied over the surface of the filter by means of rotary distributors, mechanical discs, fixed nozzles or tip troughs. Trickling filters are the most common type of secondary treatment and are preceded by primary settling tanks or fine screens. They are used to stabilize or oxidize, with the aid of biological action, organic matter, and to remove solids which have not been removed by preceding treatment.

21. Operation

A. Spray nozzles or distributor orifices should be inspected daily. All clogged nozzles and orifices should be cleaned and all broken ones replaced. Special care should be exercised during winter months to prevent freezing.

B. The distribution piping or rotary distributor arms should be flushed once a week. This may be accomplished by removing the end nozzles on laterals or by opening the end gates on distributor arms.

C. The nozzles and distributor arms and orifices should be kept in adjustment to assure equal distribution over the entire filter surface.

D. The surface of the filter bed should be kept free from vegetable growths.

E. The formation of ponds or "pooling" on the surface of the filter bed may be remedied or prevented by one of the following methods:

1. Flush the surface of the filter with a firehose.
2. Rake or fork the surface.
3. Punch holes through the top layer of the filter medium with iron bars.
4. Make heavy applications of chlorine or chlorinated lime to the filter-bed influent at the dosing tanks for short periods once a week.
5. Put units out of service occasionally for a period of twelve to forty-eight hours except during cold weather.

F. The presence of large numbers of filter flies may be controlled by periodic flooding of the filter beds, by heavy doses of chlorine or D.D.T. in certain forms in the sewage applied to the beds, or by dosing sections of the filter at excessive rates for short periods of time.

G. The underdrains should be flushed out regularly with water hose or other suitable flushing device, if the filters are so constructed as to make this possible.

Section XI SECONDARY OR RESETTLING TANKS

22. Description and Purpose

Secondary or resettling tanks are similar to primary settling tanks in design and are used to remove the settleable suspended solids which are present in the effluents from trickling filters.

23. Operation

A. The sludge should be removed frequently to prevent septic action and gasification of the solids which are settled out in the tank. Once each week should be the minimum in the winter and at least daily in the summer months.

B. The sludge should ordinarily be discharged into the primary settling tanks, preferably into the tank inlet.

Section XII SLUDGE DRYING BEDS

24. Description and Purpose

Sludge drying beds consist of large drained beds of layers of sand and gravel onto which digested or chemically conditioned sludge is discharged to reduce its water content so that it may be handled readily.

25. Operation

A. Sludge beds should not be filled to a depth of over twelve inches or to such a depth that the sludge cake cannot be removed within two weeks in good drying weather.

B. If drying is slow because of clogged beds, a thin layer of material (usually sand) should be removed from the surface of the drying bed and replaced with clean material.

C. The surface of the drying bed should be kept clean and free from all previously discharged sludge. *Never discharge wet sludge on partially dried sludge.*

D. The surface of the sludge drying beds should be kept level to afford an even distribution of sludge over the surface of the bed.

E. Remove the sludge just as soon as it may be handled with a fork.

F. Dried sludge may be used for fill, may be buried or spread upon the ground where it will not be carried into a stream or watercourse by rain.

G. In many communities, the sludge is readily disposed of by giving or selling it to nearby farmers for use as a soil conditioner. It is not advisable, however, to use it for the fertilization of fruits or vegetables which may be eaten uncooked.

Section XIII CHLORINATION UNITS

26. Description and Purpose

Chlorination units consist of a chlorinator and a chlorination chamber or contact tank in which chlorine is added to the sewage and contact is maintained for a period of thirty minutes to prevent bacterial contamination of streams or other bodies of water used for domestic water supply or for recreational or industrial purposes.

The effective chlorination of sewage or sewage effluents depends upon the presence of sufficient quantity of chlorine in all portions of the sewage for a time long enough to provide the necessary period of contact between the disinfectant and the bacteria. Any interruption in the chlorination process will be followed at once by the delivery of unchlorinated sewage even though other portions of the sewage may have been properly disinfected previously. When chlorine is added to sewage, it reacts with the organic matter in the sewage and is absorbed. The rate of this absorption depends upon the temperature of the sewage, the amount of organic matter, and the dose of chlorine. The first of these factors cannot be controlled so the net result has to be ascertained by tests for residual chlorine in the sewage which will indicate whether the chlorine rate should be increased or decreased.

Residual chlorine in sewage will react with a prepared solution of orthotolidin to form a yellow color, the intensity of which is proportional to the amount of residual chlorine in the sewage. In making this test, the intensity of the color is compared with standard colored solutions which are prepared to match the colors produced by graded amounts of residual chlorine. The turbidity of the sewage is compensated for by placing a bottle of the sewage in front of the standard color solution as described later under Appendix I.

Experience has shown that most sewages can be effectively chlorinated when chlorine is added in sufficient quantity to produce a residual chlorine concentration of at least 0.5 parts per million in fifteen minutes after the chemical is introduced into the sewage. Thus, the dose of chlorine is varied in accordance with the rate of absorption of the disinfectant as indicated by the amount of residual chlorine remaining at the end of the fifteen-minute contact period.

The strength of any sewage varies greatly with seasonal changes, with the days of the week, and during the hours of the day. The amount of chlorine required varies accordingly. Unless it is possible to make regularly frequent tests throughout each, a series of tests should be made to determine what time of day the most concentrated and heaviest doses of sewage reach the point of chlorination, and, thereafter, tests should be made at that time every day. This occurs some time during the forenoon in most plants. It is unwise to attempt to adjust chlorine dosage too closely; chlorine is comparatively cheap and an overdose will seldom do any harm.

27. Operation

A. Chlorine should be applied in such quantity that there will be a residual of at least 0.5 parts per million as determined by the ortho-tolidin test after fifteen minutes contact with the sewage effluent.

B. The test for residual chlorine should aways be made at the time when the sewage effluent is the strongest or when it requires the largest amount of chlorine for treatment.

C. The chlorine tank should be weighed each day at the same time to ascertain the amount of chlorine used.

D. The chlorine must be applied continuously in the proper quantities.

E. Before connecting a new chlorine cylinder to the control apparatus, blow off some of the chlorine from the new cylinder into the air in order to prevent clogging of the apparatus.

F. Examine the chlorine apparatus daily and if any trouble is found which cannot be corrected by the operator notify the manufacturer at once.

G. It is not advisable to draw more than forty pounds of chlorine from any one cylinder in a twenty-four hour period because of the danger of "freezing" and slowing up the chlorine flow. If more chlorine is necessary, two or more tanks should be connected and used in parallel.

H. The operator should always have on hand a stock of the usual replaceable parts for the chlorine apparatus, and an extra supply of chlorine tanks.

I. Leaks in the chlorine apparatus may be detected by the formation of white fumes when tested in the immediate vicinity with the vapors from an ammonia solution. (Household ammonia is satisfactory.)

J. During cold weather heating facilities should be provided to maintain a temperature of 60° F., and never less than 50° F., in order to prevent so-called "freezing" in the chlorinator and stoppage of the chlorine flow.

K. Chlorine is a liquid when under pressure in the cylinders and is an irritating gas which is heavier than air when released. It may produce serious after-effects if inhaled. A satisfactory gas mask should be available at all plants where chlorine is handled.

Section XIV PLANT OPERATION REPORT FORM

28. Description and Purpose

A report form for a sewage treatment plant is a chart on which certain readings, measurements, conditions and duties performed concerned with the operation of the plant are recorded.

Regardless of the size of the plant or the number of employees, certain operation records should be kept. The keeping of a report form is essential for the intelligent reporting of plant operations, and in establishing the need for sufficient funds for necessary repair and replacement of equipment. Plants should be under the direct supervision of a superintendent or designated member of the council to whom all reports should be made.

The following report form and explanation may serve as a guide in the preparation of a form for individual plants.*

*Representatives of the Department of Health are available for consultation concerning necessary reports for individual plants.

REPORT ON OPERATION OF SEWAGE TREATMENT PLANT AT _____ For Month of _____ 19__

Date	GENERAL								IMHOFF TANK							SLUDGE REMOVED					DOSING TANK			TRICKLING FILTER				RESETTLING TANK			SETTLEABLE SOLIDS C.C. PER LITER				STABILITY		Units Bypassed	Remarks	SETTLING TANK			SLUDGE DIGESTOR						CHLORINATION					
	Time	Hours of Plant	Weather	Wind	Temperature Air	Temperature Sewage	Sewage Flow	Screen Cleaned	Skimmed	Slats Cleaned	Flow Reversed	Scum Broken	Scum Depth	Sludge Depth	pH Sludge	From Tank Cu. Ft.	Color	Odor	From Bed Cu. Ft.	Drying Time	Counter Reading	Cleaned	Filling Time	Nozzles Cleaned	Underdrains Cleaned	Filter Pooling	Filter Sloughing	Skimmed	Sludge Removed	Cleaned	Plant Influent	Tank Effluent	Filter Effluent	Plant Effluent	Temp Eff.	Filter Effluent	Plant Effluent			Skimmed	Mechanism Operated	Sludge Removed	Scum Depth	Sludge Depth	Temperature Heater	Temperature Sludge	pH Sludge	Gas Cu. Ft.	Weight Tanks	Pounds Used	Rate Day	Rate Night	Residual Effluent	Time
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
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40. Quantity Screenings daily _____ disposed of by _____
41. Sludge from bed is disposed of by _____
42. Conditions below plant outlet _____
43. Method measuring flow _____

44. Power Consumption _____
45. General Remarks _____

Operator _____

29. Explanation of the Information Which Should Be Recorded on the Sheet Entitled "Report on the Operation of Sewage Treatment Plants"

Column
Number

1. Give the time of day that the observations are made.
2. State the number of hours spent at the plant by the operator.
3. Weather conditions; e.g., F=Fair, C=Cloudy, R=Rainy, S=Snow.
4. Direction from which the wind is blowing.
5. Air temperature outside (F. °) at observation time.
6. Raw sewage temperature (F. °).
7. Flow of sewage in gallons per 24 hours at observation time or if meter is used, total flow over 24 hours previous.
8. Give the number of times screen is cleaned during the day.
9. Make a cross (x) for the days when floating solids are removed from the surface of the settling chamber.
10. Make a cross (x) on the days when slopes of settling compartments are squeegeed and the slots cleaned.
11. Make a cross (x) on the days when the direction of flow across the tank is reversed.
12. Make a cross (x) on the days when the scum in the gas vents is broken up.
13. State the depth in feet of the scum in the gas vents.
14. State the depth of the sludge in the tank in feet from the water surface measured once a month or more often.
15. State the pH value of the sludge in the digestion chamber once a month or more often.
16. State the number of cubic feet of wet sludge removed from the digestion chamber to the sludge drying beds.
17. State the color of the sludge removed.
18. State the odor of the sludge removed.
19. State the number of cubic feet of dried sludge removed from the sludge drying beds.
20. State the number of days required to dry the sludge to a condition suitable for removal.

Column Number

21. Reading of the dosing counter each day or the total number of dosing tank discharges (when counter is provided).

22. Make a cross (x) on the days the dosing tank is cleaned.

23. State the time in minutes that is required to fill the dosing tank at observation time.

24. State the number of nozzles cleaned each day.

25. Make a cross (x) on the days the underdrainage system of the filter is cleaned.

26. Make a cross (x) on the days indications of pooling appear on the surface of the filter and describe under the column headed remarks.

27. Make a cross (x) on the days when there is an unusual quantity of solid material discharged from the filter bed and describe under column headed remarks.

28. Make a cross (x) on the days when the floating solids are removed from the surface of the resettling tank.

29. Make a cross (x) on the days when sludge is removed from the resettling tank.

30. Make a cross (x) on the days when the sides and slopes of the resettling tanks are cleaned.

31. Settleable solids in the raw sewage (c.c. or ml. per liter after one-hour settling period) determined by Imhoff cone test daily.

32. Settleable solids in Imhoff tank effluent as in 31.

33. Settleable solids in the effluent from the filter bed as in 31.

34. Settleable solids in the plant effluent as in 31.

35. State the temperature (F. °) effluent of the plant.

36. State the number of days for decolorization of methylene blue in the sample of the filter bed effluent at least once each week.

37. Putrescibility of final effluent as in 36.

38. State units of the plant by-passed and number of hours each. Also reason for by-passing. Use column under remarks where necessary.

39. Use this column to more fully describe special conditions under other columns. Also note any unusual condition around the plant or in the stream used as the outlet.

40. State the quantity of screenings removed each day in cubic feet or gallons and method of disposal.

41. State where the sludge from the drying bed is disposed of and whether it is used for any useful purpose.

42. Describe conditions in the stream into which the effluent from the plant is discharged, such as sludge deposits, odors, floating solids and growths.

43. State how the rate of flow is determined for column 7.

44. Give total power consumption for the plant and such additional information regarding power as may be desired by the municipality.

45. Describe any operating problems which affect the efficiency of the plant, such as industrial wastes, storm flows, etc.

46. Make a cross (x) on days when floating material is removed from the surface of the settling tank.

47. State the number of hours clarifier mechanism is operated.

48. State cubic feet of settled sludge removed from the settling tank during the day. This may be determined by timing the pump operation and peridoically measuring the pump discharge.

49. State depth of scum in feet on the surface of the digestor.

50. State the depth of the sludge in feet in the digestor.

51. State temperature (F. °) of the water circulating in the digestor at the outlet of the coils.

52. State the temperature (F. °) of the sludge in the digestor. The overflow liquor may be used as an indicator.

53. State pH value of the digesting sludge.

54. State cubic feet of gas produced from the digesting sludge per day.

55. State total weight of chlorine cylinders in use at the same time each day.

56. State actual weight of chlorine used during preceding 24 hours.

57. State rate of application of chlorine in pounds per 24 hours as indicated by the monometer or reading on the chlorinator during the day.

58. State the rate of chlorine application as in 57 during the night.

59. State results of residual chlorine test in parts per million made on the sample collected at the outlet of the contact chamber.

60. State the time of making chlorine test 59.

Appendix I

Simple Laboratory Methods for the Control of the Operation of Sewage Treatment Plants

I. PUTRESCIBILITY (Methylene Blue Test)

Sewage is composed of organic and inorganic substances suspended or dissolved in water. Generally, the strength of sewage depends on the quantity and state of oxidation of organic* matter present. The Biochemical Oxygen Demand and the Methylene Blue Putrescibility tests for sewage are based on the amount of oxygen utilized by the sample during the testing period.

The oxygen required to stabilize dissolved and suspended organic matter in sewage is derived from oxygen dissolved in the water and also from oxygen combined with nitrogen in the form of nitrites and nitrates. If the available oxygen is not sufficient for oxidation of all the organic matter, another form of decomposition occurs. This secondary decomposition is known as septic or anaerobic decomposition.

The Methylene Blue test involves a determination of the time necessary for utilization of all available oxygen in a sample, the sample being placed in a tightly stoppered bottle and maintained at a uniform temperature. A dye known as methylene blue, added to a sample as an indicator at the start of a test, will be decolorized when the available oxygen is used up. The time required for such decolorization is a measure of the strength of the sample.

This test is not applicable in the presence of free chlorine or other germicides.

Equipment

½ doz. clean glass-stoppered bottles, 6 oz. capacity.

½ doz. pipettes, 1 milliliter capacity, graduated in tenths of a milliliter.

½ doz. drinking glasses or water tumblers.

Preparation of Reagent

Methylene Blue — Dissolve 0.5 grams of the double zinc salt or commercial variety of methylene blue in distilled water, and dilute to one liter.

Procedure

Collect enough sewage from the effluent channel to half fill a quart bottle. Stopper the bottle and shake violently for three minutes and then allow the foam to subside. Fill a clean, six-ounce, glass-stoppered bottle with the aerated sewage; add 0.5 milliliters of methylene blue solution below the surface of the liquid in the bottle; replace the glass stopper in such a manner that no air bubbles remain in the bottle.

*Occasionally inorganic matter may affect the strength of the sewage.

Half fill a drinking glass with water and place the sample bottle upside down in the glass. The sample should now be placed in a room or cabinet where the temperature is constant at some point between 64° F. and 72° F. Observe daily and record the number of days elapsing before the blue color disappears. If the sample does not lose its color in 10 days, the effluent may be considered sufficiently stable. A strong sewage will decolorize the methylene blue in less than 10 days and a weak sewage in more than 10 days.

The bottles may be kept clean and free from deposits of blue color and iron by washing with 1:1 solution of hydrochloric or muriatic acid. They should then be thoroughly rinsed out with clean water. Occasional washing with a warm soap or soap powder solution, using a small wire and bristle brush followed by thorough rinsing with clean water, will remove grease from the bottles.

One-half dozen bottles, which should be labeled, are sufficient for the determination twice each week for any one sampling point.

II. SETTLEABLE SOLIDS

An Imhoff cone is a large glass cone of one liter capacity or approximately one quart. The lower end of the cone is graduated in cubic centimeters.

It will be necessary to have at least four such cones for a daily determination of settleable solids, allowing one each for raw sewage, primary settling tank effluent, filter effluent and final effluent samples.

The test is made by filling the Imhoff cone to the one-liter mark, allowing it to stand for two hours and observing the amount of solid material deposited in the lower end of the cone. This procedure should be standardized and *carried out in exactly the same way each day* in order to get comparable results.

If possible, the samples should be collected at approximately 11 a.m. or other time to get a representative sample, and immediately transferred to the cones for the test. After standing for 15 minutes, each cone should be gently rotated to dislodge suspended matter from the sides of the cone.

The cones should be thoroughly cleansed daily, using a long handled brush and a warm soap or soap powder solution. Thorough rinsing with clean water should follow such cleansing.

If there is any appreciable increase in the amount of settleable solids in the primary settling tank effluent or final effluent, an investigation should be made of the plant and unsatisfactory conditions remedied.

III. ORTHO-TOLIDIN TEST FOR RESIDUAL CHLORINE

Equipment

Four clear glass bottles, 4-oz. capacity, such as are commonly used by druggists, fitted with glass stoppers. If rubber stoppers are used, they should

be boiled for one-half hour in water containing bicarbonate of soda and then in plain water. One wide-mouth bottle of about one pint capacity for collecting sample.

Reagents

One liter of prepared ortho-tolidin solution, preferably the 18 per cent acid solution.

Color Standards

These are prepared from two solutions of definite concentration — copper sulphate and potassium dichromate.

Standard Color Solution Equivalent to 0.5 p.p.m. Residual Chlorine

Reagents: (a) Copper sulphate solution. Dissolve 3.0 grams of copper sulphate and 1 ml. of concentrated sulfuric acid in distilled water and make up to 100 ml.

(b) Potassium dichromate solution. Dissolve 0.5 grams of potassium dichromate and 1.0 ml. of concentrated sulfuric acid in distilled water and make up to 1 liter.

Place 4 ml. of copper sulphate solution and 32 ml. potassium dichromate solution in a graduate, dilute to 100 ml. with distilled water. This standard should be placed in a bottle and labeled "0.5 p.p.m. Standard."

Directions for Making Test

1. Fill one of the four-ounce bottles nearly full with chlorinated sewage which is to be tested, taken at a place near the point of application of the chlorine but far enough away to provide opportunity for the chlorine to mix with the sewage before the sample is collected.

2. Allow the sample to stand 15 minutes after it is collected unless such period of contact has already elapsed since the addition of chlorine to the sewage sample.

3. Add 1 c.c. of the standard ortho-tolidin solution to the sample.

4. Mix and allow to stand ten minutes. If the sewage is very cold, warm slightly by holding the bottle between the hands or by heating over a fire after adding the solution. Care should be taken not to heat the sewage warmer than room temperature or the accuracy of the test will be affected.

5. Compare the color produced with that of the "standard" noted above. As the turbidity of the sewage or sewage effluent makes direct comparison

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Note: Complete information concerning laboratory determinations is contained in "Standard Methods for the Examination of Water and Sewage" published by the American Public Health Association, 450 Seventh Avenue, New York City.

inaccurate, place in front of the "standard" a four-ounce bottle filled with the same sewage or sewage effluent but without the reagent. Also, in order to equalize the depth of glass and of liquid looked through, place back of the sample which has been treated with ortho-tolidin solution a four-ounce bottle of distilled water. Now place the two sets, each consisting of two bottles, side by side, near a window and compare the color intensity by looking through two bottles in each instance.

6. If the color is lighter than that in the 0.5 p.p.m. standard, the dose of chlorine should be increased. Then repeat test to check results, if dose of chlorine is varied, allowing sufficient time for the changed chlorine dose to reach the sampling point.

IV. HYDROGEN-ION CONCENTRATION

This test is a very valuable indication of the condition of the sludge in an Imhoff, separate-sludge-digestion, or septic tank. It may also be used to determine the alkalinity or acidity of sewage or effluents.

The digestion of sludge is affected by its alkalinity or acidity. An alkaline condition is desirable for satisfactory sludge digestion. Some knowledge of the condition of the sludge can be secured by testing it with litmus paper, the litmus becoming blue with an alkaline sludge and red with an acid sludge.

However, a much better knowledge of the condition of a sludge is obtained by means of Hydrogen-Ion Determinations. These tests are in reality very simple and depend on the color produced by the addition of a small amount of a dye solution to the sample and comparison of the resulting color with color standards. These standards may be either tubes of standard color solutions or standard colored glass discs such as are used in certain types of comparators. The results of this test are expressed in numbers designated by the symbol pH. Neutrality or the hydrogen-ion concentration of pure distilled water is indicated by a pH value of 7.0, any value less than 7.0 being considered acid and any value over 7.0 alkaline.

It has been found that sludge digestion is most favorable with a pH value of from 7.2 to 7.6, and that if the pH falls to 7.0 or below, foaming or other unsatisfactory conditions are likely to occur.

Complete outfits for making the tests are now available and may be purchased from chemical supply houses.

A brief resume of the operating procedure for this determination—using standard color solutions—follows:

The sample, if sludge, should be prepared for examination usually by filtering through filter paper which has been water-washed previously. The determination of the pH is then made of the filtered liquid, known as the filtrate. The sample may also be prepared for the test by diluting it with

pure water having a pH value of about 7.0 preferably. Dilution, however, should not be over 1/15.

One of the graduated tubes is filled with the prepared sample and 0.5 c.c. of the indicator solution added. As the turbidity of the sample usually makes direct comparison inaccurate, some compensation must be made for this turbidity. This may be done by using some apparatus such as a wooden block with four vertical and two horizontal holes slightly larger than the diameter of the tubes.

To compensate for the turbidity of the sample, a graduated tube of the same size as the standard is filled with the filtered sample to which no color or reagent has been added, and placed in front of the color standard tube. In order to equalize the depth of glass and liquid looked through, place a tube of distilled water back of the treated sample.

The above apparatus is optional. Complete testing outfits are now on the market by which this determination can be made even simpler. In some of the sets, standard colored glass discs are used in place of a standard color solution. One indicator solution, namely, brom thymol blue, which has a pH range of 6.0 to 7.6 is usually sufficient for ordinary conditions.

The filtration of the sludge sample or the addition of dilution water is usually necessary when a pH set is used with the tubes of ordinary size, i.e., those having a diameter of 1 m.m. or greater. Either of these procedures may introduce errors, and is also time-consuming.

A direct-reading method in which tubes of a smaller size are used is frequently more desirable. This method may be carried out as follows:

With a specially graduated pipette a sample of sludge is measured into a depression of the porcelain plate. The proper quantity of indicator is then added and the sludge and the indicator mixed by inserting the tip of the pipette into the bottom of the depression and drawing up and blowing out the mixture several times. The mixture is then drawn up into the pipette and its color is compared with that of the standards. These are tubes of the same diameter as the pipette containing the indicator in buffer solutions of different pH values in the range of the indicator. These standard tubes are mounted on a white celluloid card.

Appendix II

Operating Hazards and Safety Precautions in Sewage Treatment Plants

1. GAS AND EXPLOSION HAZARDS IN SEWAGE TREATMENT PLANTS

Explosions in sewage treatment plants are practically without exception caused by the ignition of gases or vapors mixed with air in proportions favorable for rapid combustion.

The gases or vapors responsible are derived from two main sources:

a. Gasoline and allied products brought into the plant with the sewage, vaporized in screen chambers, wet wells or other enclosed spaces to form highly explosive mixtures with the proper proportions of vapor and air, and manufactured gas from leaky gas mains which may find its way into sewers and through them into the treatment plant.

b. Those gases caused by the decomposition of the organic matter settled from the sewage. This gas, which may be generated from decomposing matter in sewers or sewage treatment plants, is a mixture of Methane (CH_4) 60 to 80 per cent; Carbon Dioxide (CO_2) 20 to 30 per cent; Nitrogen (N) up to 5 per cent; Oxygen (O) a trace; Hydrogen (H) up to 8 per cent; and Hydrogen Sulphide (H_2S) 0 to 1½ per cent.

This mixture of gases, often labeled sewer gas or sewage gas, is highly explosive when mixed in the proportion of 8 to 18 per cent gas with air.

The gas presents not only an explosion hazard but an asphyxiation hazard as well. Breathed into the lungs it may cause headache, sleepiness or asphyxiation.

This gas is almost odorless unless a small amount of Hydrogen Sulphide, rotten egg odor, is present in the mixture of component gases. It has a heating value of 650 to 750 B.T.U. per cubic foot and is lighter than air. (Its weight is ¾ that of an equal volume of air.)

Danger Points

Unventilated control manholes, screen chambers and wet wells of pumping plants where turbulent flow releases gases and increases the vaporization of gasoline or allied products to form explosive mixtures with the air. Dry wells, heater and control rooms of pumping plants and pipe galleries where leaks in sewage, sludge, and gas piping may cause gas accumulations from the

gas generated by decomposition of organic matter in the pipe line or in the digester. Imhoff tanks and separate sludge digesters where active decomposition of organic matter is producing gas continuously.

Precautions for Safety

a. Always be careful.

b. Do not go into doubtful enclosed spaces without having first tested for gas. If you must go in without testing, put on a safety harness with the attached life line in the hands of two able assistants who remain on the surface. Do not smoke. Keep open flame away.

c. Remember that wherever an explosion hazard exists an asphyxiation hazard exists also.

d. Wear rubber soled shoes and take great care in the use of tools so as not to cause sparks when working in dangerous places.

e. See that all vents to enclosed spaces are clear of obstructions. Remove manhole covers or open wide all hatch covers to the open air for a reasonable period of time before entering enclosed spaces.

f. The housing to Imhoff tanks should be well posted with "No Smoking" signs, one at each entrance and several inside the housing. This unit should have ample roof ventilation. Window vents should be opened for additional ventilation when the operator is working here.

g. Gas in separate sludge digesters and the gas piping system should be kept under pressure at all times. It may be desirable to add water or clarified sewage to the digester to maintain pressure when drawing ripened sludge. The digester and gas piping system should be examined occasionally for leaks. The water level should be maintained in automatic drip traps. Relief vents should never discharge into enclosed spaces and they should be examined frequently for clogging by frost or other material.

h. *Develop an awareness to the plant danger points for gas and explosion hazards. Do not smoke when working around these places. Keep open flames and blow torches away. Remember that an explosion hazard is practically always an asphyxiation hazard. Do not enter doubtful places when alone. As a minimum precaution wear a safety harness and place the life line in the hands of two able helpers. Always be careful.*

2. SAFETY PRECAUTIONS

A. A telephone should be available at the plant when practicable so that the operator, if alone, may make regular reports to a responsible person.

B. Portable manhole guards should be used at all times where a manhole cover or grating has been removed.

C. Walks, gratings, stairways and guard rails should be installed to make access to all units as safe as possible.

D. A yard light should be provided for safety in night operation.

E. Guards should be provided around all moving parts of equipment such as pump shafts, fly wheels, etc.

F. Lubrication should not be performed while the equipment is in operation.

G. Floors and walkways should be kept dry and clean to prevent slipping.

H. Adequate washing and shower facilities should be provided.

I Cuts, burns, etc., should be treated immediately and carefully protected until healed.

J. Direct contact of the hands with sewage or sludge should be avoided.

K. Employees should be vaccinated against typhoid fever.

APPENDIX III

Discharge in Gallons per Minute over Right-Angled V-Notched Weir

by Formula $Q = 2.52\ H^{2.47}$

H In.	H Ft.	Q-gallons per minute	H In.	H Ft.	Q-gallons per minute	H In.	H Ft.	Q-gallons per minute
0–	0.0		4–			8–		
1/8	.010		1/8	0.344	81.06	1/8	0.677	431.6
1/4	.021		1/4	.354	87.00	1/4	.688	449.1
3/8	.031		3/8	.365	93.83	3/8	.698	465.4
1/2	.042		1/2	.375	100.3	1/2	.708	482.0
5/8	.052	0.762	5/8	.385	107.0	5/8	.719	500.7
3/4	.062	1.177	3/4	.396	114.8	3/4	.729	518.1
7/8	.073	1.762	7/8	.406	122.0	7/8	.740	537.6
1–	.083	2.419	5–	.417	130.4	9–	.750	556.5
1/8	.094	3.289	1/8	.427	138.2	1/8	.760	574.2
1/4	.104	4.223	1/4	.437	146.4	1/4	.771	595.0
3/8	.115	5.413	3/8	.448	155.6	3/8	.781	614.2
1/2	.125	6.650	1/2	.458	164.4	1/2	.792	635.8
5/8	.135	8.043	5/8	.469	174.3	5/8	.802	655.8
3/4	.146	9.759	3/4	.479	183.6	3/4	.812	676.2
7/8	.156	11.50	7/8	.490	194.2	7/8	.823	699.1
2–	.167	13.60	6–	.500	204.1	10–	.833	720.3
1/8	.177	15.70	1/8	.510	214.4	1/8	.844	743.9
1/4	.188	18.22	1/4	.521	226.0	1/4	.854	765.9
3/8	.198	20.74	3/8	.531	236.8	3/8	.865	790.5
1/2	.208	23.39	1/2	.542	249.2	1/2	.875	813.2
5/8	.219	26.57	5/8	.552	260.7	5/8	.885	836.4
3/4	.229	29.67	3/4	.562	272.5	3/4	.896	862.3
7/8	.240	33.31	7/8	.573	285.8	7/8	.906	886.3
3–	.250	36.85	7–	.583	298.3	11–	.917	913.1
1/8	.260	40.59	1/8	.594	312.4	1/8	.927	937.9
1/4	.271	44.97	1/4	.604	325.6	1/4	.938	965.6
3/8	.281	49.18	3/8	.615	340.4	3/8	.948	991.2
1/2	.292	54.07	1/2	.625	354.4	1/2	.958	1017.3
5/8	.302	58.76	5/8	.635	368.4	5/8	.969	1046.4
3/4	.312	63.69	3/4	.646	384.4	3/4	.979	1073.3
7/8	.323	69.38	7/8	.656	399.2	7/8	.990	1103.3
4–	.333	74.80	8–	.667	416.0	12–	1.000	1131.1

1 c. f. s. = 448.83 gpm = 646,205 GPD = 1.983 Ac. Ft. p. d.

Appendix IV

STATE WATER POLLUTION CONTROL ACT

Laws of 1945, Chapter 395

CHAPTER 395 — S. F. No. 460

AN ACT relating to the pollution of any waters of the state and to the disposal of sewage, industrial waste, and other wastes, and amending Minnesota Statutes 1941, Section 144.38.

Be it enacted by the Legislature of the State of Minnesota:

Section 1. Subdivision 1. The following words and phrases when used in this act, unless the context clearly indicates otherwise, shall have the meanings ascribed to them in this section.

Subd. 2. "Sewage" means the water-carried waste products from residences, public buildings, institutions or other buildings, including the excrementitious or other discharge from the bodies of human beings or animals, together with such ground water infiltration and surface water as may be present.

Subd. 3. "Industrial waste" means any liquid, gaseous or solid waste substance resulting from any process of industry, manufacturing trade or business or from the development of any natural resource.

Subd. 4. "Other wastes" means garbage, municipal refuse, decayed wood, sawdust, shavings, bark, lime, sand, ashes, offal, oil, tar, chemicals, and all other substances not sewage or industrial waste which may pollute or tend to pollute the waters of the state.

Subd. 5. "Pollution" means the contamination of any waters of the state so as to create a nuisance or render such waters unclean, or noxious, or impure so as to be actually or potentially harmful or detrimental or injurious to public health, safety or welfare, to domestic, commercial, industrial or recreational use, or to livestock, wild animals, bird, fish, or other aquatic life.

Subd. 6. "Sewer system" means pipe lines or conduits, pumping stations, and force mains, and all other constructions, devices, and appliances appurtenant thereto, used for conducting sewage or industrial waste or other wastes to a point of ultimate disposal.

Subd. 7. "Treatment work" means any plant, disposal field, lagoon, dam, pumping station, constructed drainage ditch or surface water intercepting ditch, incinerator, area devoted to sanitary land fills, or other works not specifically mentioned herein, installed for the purpose of treating, stabilizing or disposing of sewage, industrial waste, or other wastes.

Subd. 8. "Disposal system" means a system for disposing of sewage, industrial waste and other wastes, and includes sewer systems and treatment works.

Subd. 9. "Waters of the state" means all streams and lakes, including all rivers and lakes bordering on the state, marshes, watercourses, state, county, town or judicial drainage systems and other bodies of water, natural or artificial, public or private, of such character that the pollution thereof may create a nuisance or be either actually or potentially harmful or detrimental to the public health, safety or welfare, or to domestic, commercial, industrial or recreational use, or to livestock, wild animals, birds, fish, or other aquatic life.

Subd. 10. "Person" means any municipality, governmental subdivision, public or private corporation, individual, partnership or other entity.

Sec. 2. Subdivision 1. There is hereby created a water pollution control commission, hereinafter referred to as the commission, which shall consist of the secretary and executive officer of the state board of health, the commissioner of conservation, the commissioner of agriculture, dairy and food, the secretary and executive officer of the state livestock sanitary board, and a member at large who shall be appointed by the governor and shall hold office for four years and until his successor shall have been appointed and qualified. The member at large shall receive no compensation for his services but he shall receive necessary and actual traveling and subsistence expenses for any meeting of the commission or for trips which he may make in connection with the work of the commission. The other members of the commission shall receive no additional compensation for their services as members of the commission, but shall receive their necessary and actual traveling and subsistence expenses while engaged in the business of the commission, which shall be paid from the appropriations to their several departments.

Subd. 2. The commission shall hold quarterly regular meetings each calendar year at a time and place to be fixed by the commission. It shall select at its first meeting following the passage and approval of this act two of its members to serve as chairman and vice-chairman, respectively, and at the first regular meeting in each calendar year thereafter which shall be held in January, it shall select two of its members to serve for the ensuing year as chairman and vice-chairman, respectively. The secretary and executive officer of the state board of health shall serve as secretary of the commission and shall have custody of its files and records except such as are required to be filed with the secretary of state or otherwise. Special meetings of the commission may be called by the chairman or by any two other members upon at least two days' written notice mailed to each other member of the commission or delivered at their respective offices. A majority of members of the commission shall constitute a quorum.

Sec. 3. Subdivision 1. The commission is hereby given and charged with the following powers and duties:

Subd. 2. To administer and enforce all laws relating to the pollution of any of the waters of the state;

Subd. 3. To investigate the extent, character, and effect of the pollution of the waters of the state and to gather data and information necessary or desirable in the administration or enforcement of pollution laws, and to make such classification of the waters of the state as it may deem advisable;

Subd. 4. To establish and alter such reasonable pollution standards for any waters of the state in relation to the public use to which they are or may be put as it shall deem necessary for the purposes of this act;

Subd. 5. To make and alter reasonable orders requiring the discontinuance of the discharge of sewage, industrial waste or other wastes into any waters of the state resulting in pollution in excess of the applicable pollution standard established under Subdivision 4 of this section;

Subd. 6. To require to be submitted and to approve plans for disposal systems or any part thereof and to inspect the construction thereof for compliance with the approved plans thereof;

Subd. 7. To issue, continue in effect or deny permits, under such conditions as it may prescribe for the prevention of pollution, for the discharge of sewage, industrial waste or other wastes, or for the installation or operation of disposal systems or parts thereof;

Subd. 8. To revoke or modify any permit issued under this act whenever it is necessary, in the opinion of the commission, to prevent or abate pollution of any waters of the state;

Subd. 9. To prescribe and alter rules and regulations, not inconsistent with law, for the conduct of the commission and other matters within the scope of the powers granted to and imposed upon it by this act, provided that every rule or regulation affecting any other department or agency of the state, or any person other than a member or employee of the commission shall be filed with the secretary of state; and

Subd. 10. (1) To conduct such investigations and hold such hearings as it may deem advisable and necessary for the discharge of its duties under this act, and to authorize any member, employee or agent appointed by it to conduct such investigations or hold such hearings.

(2) In any such hearing or investigation, any member of the commission, or any employee or agent thereto authorized by the commission, may administer oaths, examine witnesses and issue, in the name of the commission, subpoenas requiring the attendance and testimony of witnesses and the production of evidence relevant to any matter involved in any such hearing or investigation. Witnesses shall receive the same fees and mileage as in civil actions.

(3) In case of contumacy or refusal to obey a subpoena issued under this section, the district court of the county where the proceeding is pending or in which the person guilty of such contumacy or refusal to obey is found or resides, shall have jurisdiction upon application of the commission or its authorized member, employee or agent to issue to such person an order requiring him to appear and testify or produce evidence, as the case may require, and any failure to obey such order of the court may be punished by said court as a contempt thereof.

Sec. 4. Subdivision 1. Any person operating a disposal system, when requested by the commission, shall furnish to it any information which he may have which is relevant to the subject of this act.

Subd. 2. The commission or any employee or agent thereof, when authorized by it, may examine any books, papers, records or memoranda pertaining to the operation of a disposal system.

Subd. 3. Whenever it shall be necessary for the purposes of this act, the commission or any member, employee or agent thereof, when authorized by it, may enter upon any property, public or private, for the purpose of obtaining information or conducting surveys or investigations.

Sec. 5. Subdivision 1. No final order of the commission shall be effective as to the vested rights of any person adversely affected thereby nor as to any disposal system operated by any person unless the commision or its authorized officer, member, or agent shall have held a hearing upon the matter therein involved at which evidence may be taken, of which hearing such person shall have had notice as hereinafter provided. Any person who will be directly affected by the final order therein shall have the right to be heard at the hearing and to submit evidence thereat. Written notice specifying the time and place of the hearing shall be served by the commission upon all persons known by it to be directly affected by the final order, personally or by registered mail not less than ten days before the date of the hearing. A copy of the final order shall be served in the same manner upon all persons who entered an appearance at the hearing.

Subd. 2. Notwithstanding the provisions of Subdivision 1 of this section, the commission, when it shall have first determined that an emergency exists respecting any matter affecting the public health, may make a final order without notice and without a hearing. A copy of such final order shall be served as provided in Subdivision 1 of this section.

Subd. 3. An appeal may be taken from any final order, rule, regulation, or other final decision of the commission by any person who is or may be adversely affected thereby, or by the attorney general in behalf of the state, to the district court of Ramsey County in the manner herein provided. Within 30 days after receipt of a copy of the order, rule, regulation, or decision, or after service of notice thereof by registered mail, but not in any case more than six months after the making and filing of the order, rule, regulation or decision, the appellant or his attorney shall serve a notice of appeal on the commission, through its secretary; provided, that during such 30 day period the court may, for good cause shown, extend such time for not exceeding an additional 60 days, but not beyond the expiration of such six months' period. The notice of appeal shall refer to the action of the commission appealed from, shall specify the grounds of the appeal, including points of both law and fact which are asserted or questioned by the appellant, and may contain any other allegations or denials of fact pertinent to the appeal. The notice shall state an address within the state at which service of notice and other papers in the matter may be made upon the appellant. The original notice of appeal, with proof of service, shall be filed by the appellant or his attorney with the clerk of the court within ten days after the service of the notice, and thereupon the court shall have jurisdiction of the appeal.

Subd. 4. The appellant and the commission shall in all cases be deemed the original parties to an appeal. The state, through the attorney general, or any other person affected may become a party by intervention as in a civil action, upon showing cause therefor. The attorney general shall represent the commission, if requested, upon all such appeals unless he appeals or intervenes in behalf of the state. No bond or deposit for costs shall be required of the state or the commission upon any such appeal or upon any subsequent appeal to the supreme court or other court proceedings pertaining to the matter.

Subd. 5. The venue of an appeal may be changed by order of the court upon written consent of the parties or for cause shown, after hearing upon notice to all parties, as in a civil action, to the district court of any county in which the order, rule, regulation, or decision appealed from would take effect.

Subd. 6. Within 30 days after service and filing of the notice of appeal the commission, through its secretary, shall make, certify, and file with the clerk of the court having jurisdiction of the appeal a return comprising a copy of any application, petition, or other material paper whereon the action of the commission appealed from was based, a copy of the order, rule, regulation, or decision appealed from, a statement of any finding of fact or ruling or conclusion of law made by the commission in the matter, and such other statements, admissions, or denials upon questions of law or fact raised by the appeal as the commission may deem pertinent. Such 30 day period may be extended by the court for cause shown for not exceeding an additional 60 days. Within the time allowed for making and filing the return a copy thereof shall be mailed to or served upon the appellant or his attorney. The allegations of new matter in the return shall be deemed to be denied by the appellant unless expressly admitted, and no further pleadings shall be interposed. Otherwise the allegations of the notice of appeal and return shall have like effect as the pleadings in a civil action and shall be subject to like proceedings, so far as applicable.

Subd. 7. The appeal shall be heard and determined by the court upon the issues raised by the notice of appeal and return according to the rules relating to the trial of civil actions, so far as applicable. The court of its own motion or on application of any party may, in its discretion, take additional evidence on any issue of fact or may try any or all such issues de novo, but no jury trial shall be had. If the court shall determine that the action of the commission appealed from is lawful and reasonable, and is warranted by the evidence in case an issue of fact is involved, the action shall be affirmed. Otherwise the court may vacate or suspend the action appealed from in whole or in part, as the case may require, and thereupon the matter shall be remanded to the commission for further action in conformity with the decision of the court.

Subd. 8. The taking effect of any action of the commission shall not be stayed by an appeal except by order of the court for cause shown by the appellant. The granting of a stay may be conditioned upon the furnishing by the appellant of such reasonable security for costs as the court may direct. A stay may be vacated on application of the commission or any other party

after hearing upon notice to the appellant and to such other parties as the court may direct.

Subd. 9. In any appeal or other proceeding involving any order, rule, regulation, or other decision of the commission, the action of the commission shall be prima facie reasonable and valid, and it shall be presumed that all requirements of the law pertaining to the taking thereof have been complied with. All findings of fact made by the commission shall be prima facie evidence of the matters therein stated. The burden of proving the contrary of any provision of this subdivision shall rest upon the appellant or other party questioning the action of the commission.

Subd. 10. If no appeal be taken from an order, rule, regulation, or other decision of the commission as herein provided, or if the action of the commission be affirmed on appeal the action of the commission in the matter shall be deemed conclusive, and the validity and reasonableness thereof shall not be questioned in any other action or proceeding, but this shall not preclude the authority of the commission to modify or rescind its actions.

Sec. 6. Subdivision 1. The commission, so far as it is not inconsistent with its duties under the laws of this state, may assist and cooperate with any agency of another state, of the United States of America or of the Dominion of Canada or any province thereof in any matter relating to water pollution control.

Subd. 2. The commission may receive and accept money, property, or services from any person or from any agency described in Subdivision 1 or from any other source for any water pollution control purpose within the scope of its functions under this act, and all moneys so received are hereby appropriated for such purposes in like manner and subject to like provisions of law as the corresponding appropriations of state funds.

Sec. 7. This act shall not be construed as repealing any of the provisions of law relating to the pollution of any waters of the state, but shall be held and construed as supplementing the same and in addition to the laws now inforce, except as the same may be in direct conflict herewith.

Sec. 8. Subdivision 1. It shall be unlawful for any person to construct, install or operate a disposal system, or any part thereof, until plans therefor shall have been submitted to the commission unless the commission shall have waived the submission thereof to it and a written permit therefor shall have been granted by the commission.

Subd. 2. It shall be unlawful for any person to make any change in, addition to or extension of any existing disposal system or part thereof that would materially alter the method or the effect of treating or disposing of the sewage, industrial waste or other wastes, or to operate such system, or part thereof as so changed, added to, or extended until plans therefor shall have been submitted to the commission unless the commission shall have waived the submission thereof to it and a written permit therefor shall have been granted by the commission.

Subd. 3. Violation of any provision of this act or of any regulation adopted by the commission thereunder shall be a misdemeanor.

Subd. 4. Pollution of any waters in violation of any provisions of this act, or of any order or regulation adopted by the commission thereunder shall constitute a public nuisance, and may be enjoined and abated as such as provided by law.

Sec. 9. The commission, upon application of the appropriate person, shall issue a permit for the continuance of every disposal system now operating pursuant to proper legal authority subject, however, to the right of the commission to modify or revoke such permit in the same manner as other permits.

Sec. 10. Every person who claims damages from the holder of a permit issued hereunder for the operation of a disposal system or from any employee or agent of such permit holder for or on account of any loss or injury sustained by reason of the operation of such system in respect of the treatment or disposal of sewage, industrial waste, or other wastes therein, or by reason of the discharge of any effluent therefrom, shall cause to be presented to such permit holder and to the secretary of the commission within 30 days after the alleged loss or injury occurred a written notice, stating the time, place, and circumstances thereof, and the amount of compensation or other relief demanded. No action therefor shall be maintained unless such notice has been given, or if commenced within ten days thereafter or more than one year after the occurrence of the loss or injury.

Sec. 11. This act may be cited as the State Water Pollution Control Act.

Sec. 12. Minnesota Statutes 1941, Section 144.38, is amended to read as follows:

"144.38. Subdivision 1. The board is hereby given and charged with the power and duty of administering and enforcing all laws relating to the pollution of any of the waters of this state, so far as such pollution affects the public health.

Subd. 2. The board shall make such investigations of water pollution and the plans for the construction of works affecting water pollution as may be required by the water pollution control commission. The board shall furnish to such commission such other services as the commission may need in the administration of the State Water Pollution Control Act, including the employment of a qualified and experienced sanitary engineer, who shall be designated by the board, with the approval of the commission, to act as consultant to the commission.

Subd. 3. The board is hereby specifically authorized to cooperate with other departments of state, other state officers, with municipalities of all kinds, with other states, the United States, the Dominion of Canada or any province thereof, industries, societies, corporations, and individuals, to the end and purpose of protecting and freeing the waters of the state from pollution."

4-19-45

Appendix V
MINNESOTA DEPARTMENT OF HEALTH
Division of Water Pollution Control
Municipalities Having Sewer Systems With Sewage Treatment Plants
January 1, 1947

Location	Drainage Basin (River)	Year Const. of Municipal San. Sewer System Commenced	Year S. T. P. Constructed	Pop. (1940)	Treatment Units	Final Disposal
Ada	Red River of North	1895	1913	1,988	Septic tank	Marsh River
Adrian	Rock	1920	1920	1,066	I, Sl. B.	Kanavanzie River
Albany	Upper Mississippi	1922	1921	975	I, Sl. B.	Two Rivers
Albert Lea	Cedar	1910	1927	12,200	I, Sl. B.	Albert Lea Lake
Alexandria	Upper Mississippi	1912	1929	5,051	I, T. F., F. S., Sl. B.	Lake Winona
Amboy	Blue Earth	1922	1922	376	I, Sl. B.	Blue Earth River
Annandale	Upper Mississippi	1921	1922	755	I, Sl. B.	Pleasant Lake
Anoka	Upper Mississippi	1917	1917	6,426	I, Sl. B.	Mississippi River
Appleton	Minnesota	After 1910	1934	1,877	I, T. F., F. S., Sl. B.	Pomme de Terre River
Arlington	Minnesota	1928	1928	1,122	I, Sl. B.	High Island Creek
Aurora	St. Louis	1936	1940	1,528	I, T. F., F. S., Sl. B.	Creek to St. Louis River
Austin	Cedar	1892	1924-39	18,037	Grease Flt., Floc., P. S., H. T. F., Int. S., T. F., F. S., Cl., D., Sl., B.	Cedar River
Bagley	Red Lake	1939	1940	1,241	P. S., T. F., F. S., Cl., D., Sl. B.	Clearwater River
Barnesville	Red River of North	1909	1988	1,450	P.S., A.S., F.S., Cl., Sl. B.	Willow Creek
Baudette	Rainy	1909	1909	1,017	Septic tank	Baudette River
Bayport	St. Croix	After 1920	1940	2,633	P.S., A.S., F.S., Cl., D., Sl. B.	St. Croix River
Bemidji	Upper Mississippi	1906	1934	9,427	Grit, Com., P.S., T.F., F.S., Cl., D., Sl. B.	Mississippi River
Benson	Chippewa	1897	1936	2,729	P.S., T.F., F.S., D., Cl., Sl. B.	Chippewa River
Bertha	Upper Mississippi	1937	1937	578	I, T.F., F.S., Cl., Sl. B.	Creek east of Village
Blackduck	Red Lake	1913	1913	753	I, Sl. B.	Black Duck Lake
Blooming Prairie	Cedar	1918	1915-33	1,205	P.S., T.F., D., Sl. B.	Ditch to West Fork
Bock	Rum	1934	1934	125	I., T.F., F.S., Sl. B.	Bogus Creek
Bovey	Upper Mississippi	1910 (About)	1934	1,355	I., Sl. B.	Trout Lake
Braham	Upper Mississippi	1941	1940	578	P.S., T.F., F.S., D., Cl., Sl. B.	Ditch
Brainerd	Upper Mississippi	1919	1940	12,071	Com., P.S., T.F., F.S., Cl., D., Sl. B.	Mississippi River
Browns Valley	Minnesota	1914	1923	1,075	I., Sl. B.	Minnesota River
Buffalo	Crow	1926	1939	1,695	P.S., T.F., F.S., Cl., D., Sl. B.	Buffalo Lake
Buhl	St. Louis	Before 1909	1926	1,600	A.S., F.S., Sl. L.	Creek
Butterfield	Blue Earth	1918	1928	511	I., Sl. B.	N. B. Watonwan River

Caledonia	Lower Mississippi	1917	1917-37	1,985	I., T.F., F.S., Cl., Sl. B.	Dry run
Callaway	Red River of North	1936	1938	294	I., Sl. B.	County ditch
Calumet	Upper Mississippi	1910	1922	946	I., Sl. B.	Ditch
Canby	Minnesota	1909	1910	2,099	Septic tank	Lac Qui Parle River
Chatfield	Root	About 1911	1941	1,640	P.S., H. T.F., F.S., Cl., Sl. Chem.	Root River (North fork)
Chokio	Pomme de Terre	1937	1940	492	I., T.F., F.S., Sl. B.	Drainage Ditch
Clara City	Minnesota	1936	1937	845	I., T.F., F.S., Cl., Sl. B.	Hawk Creek
Claremont	Zumbro	1916	1916	398	I., Sl. B.	Zumbro River
Clarkfield	Minnesota	1936	1938	965	I., T.F., F.S., Sl. B.	Ditch
Clinton	Minnesota	1936	1937	630	I., Sl. B.	Dry run
Cokato	Upper Mississippi	1907	1942	1,175	P.S., H. T.F., F.S., Cl., Sl. Chem.	Sucker Creek
Coleraine	Upper Mississippi	1910 (About)	1920 (Before)	1,325	Septic tank	Trout Lake
Columbia Hts.	Upper Mississippi	1927	1938	6,035	Mpls. sewer system	Mississippi River
Cook	Rainy	1938	1940	470	I., Sl. B.	Little Fork River
Cottonwood	Minnesota	1939	1940	690	Grit P.S., H.T.F., F.S., Cl., D., Sl. B.	Cottonwood Lake
Crosby	Upper Mississippi	1919	Before 1920	2,954	Septic tank	Creek
Cyrus	Chippewa	1936	1936	357	I., Sl. B.	Chippewa River
Dawson	Minnesota	1917	1917	1,664	I., Sl. B.	Ditch to Lac Qui Parle R.
Deerwood	Upper Mississippi	1914	1917	570	I., Sl. B.	Cranberry Lake
Detroit Lakes	Ottertail	1919	1929-41	5,015	(I., T.F., F.S., Old P.) F. Screens, H.T.F., Int. S., T.F., F.S., Cl., V.F., Sl. Chem. Sl. B.	Creek to St. Clair Lake
Dilworth	Red River of North	1936	1935	1,068	Moorhead sewer system	Red River of North
Dodge Center	Zumbro	1917	1917	1,029	I., Sl. B.	Zumbro River
Duluth	Lake Superior	1883	1940	101,065	Grit, Floc., P.S., D., Cl., V.F., Inc.	Lake Superior
Edgerton	Rock	1921	1939	815	I., T.F., F.S., Sl. B.	East Fork of Rock River
Edina	Upper Mississippi	1923	1938	5,855	Mpls. sewer system	Mississippi River
Elbow Lake	Red River of North	1926	1926	1,150	Septic tank, I.	Worm Lake
Ely	Rainy	1901	1912	5,970	I., Sl. B.	Shagawa Lake
Emmons	Cedar	1923	1923	334	I., Sl. B.	Ditch to Lime Creek
Eveleth	St. Louis	1900	1914-20	6,887	I., T.F., F.S., Sl. B.	Creek to Elbow Lake
Excelsior	Minnesota	About 1927	1939	1,422	Com. P.S., T.F., F.S., S.F., D., Cl., Sl. B., Glass Covered	Lake Minnetonka
Fairfax	Minnesota		1940	1,116	P.S., T.F., F.S., Cl., D., Sl. B.	Creek to Minnesota River
Fairmont	Blue Earth	1907	1918-30-34	6,988	I., T.F., F.S., Cl., D., Sl. B.	Center Creek
Farmington	Lower Mississippi	1917	1917	1,580	I., Sl., B.	Vermillion River
Fergus Falls	Ottertail	About 1882	1936	10,848	Grit P.S., D., Cl., Sl. B.	Ottertail River
Foley	Upper Mississippi	1919	1921	961	I., Sl. B.	Stony Brook
Forest Lake	St. Croix	1919	1941	1,120	Com., P.S., P. & Sec., A.S., F.S., Cl., D., Sl. B.	Clear Lake
Fosston	Red Lake	1915	U. C.	1,271	I., T.F., F.S., Sl. B.	Poplar River
Franklin				515		
Lincoln Loc.	St. Louis	1923	1936		I., T.F., F.S., Sl. B.	Mine Cave
Higgins Loc.	St. Louis	1923	1936		I., T.F., F.S., Sl. B.	Mine Cave
Fraser (P. O. Chisholm)	St. Louis			155	I., Sl. B.	Creek to St. Louis River
Frazee	Ottertail	1941	1946	1,467	I., Sl. B.	Ottertail River
Freeport	Sauk	1920	1930	548	I., Sl. B.	Getchell Creek
Fulda	Des Moines	About 1910	1937	984	I., Sl. B.	County Drain Tile

Appendix V—Continued

MINNESOTA DEPARTMENT OF HEALTH

Division of Water Pollution Control

Municipalities Having Sewer Systems With Sewage Treatment Plants

January 1, 1947

Location	Drainage Basin (River)	Year Const. of Municipal San. Sewer System Commenced	Year S. T. P. Constructed	Pop. (1940)	Treatment Units	Final Disposal
Gaylord	Minnesota	1916	1916	1,049	I., Sl. B.	Mud and Titlow Lakes
Gibbon	Minnesota	1935	1936	761	P.S., D., Sl. B.	County Ditch to Rush River
Gilbert	St. Louis	1912	1915	2,504	I., T.F., F.S., Sl. B.	Ditch to Creek
Glencoe	Crow	1915	1934	2,387	I., A.S., F.S., Cl., Sl. B.	Buffalo Creek
Glenwood	Chippewa	1904	1933	2,564	I., T.F., F.S., Sl. B.	Ditch to L. Minnewaska
Goodhue	Zumbro	1940	1940	480	P.S.,T.F.,F.S., Cl., D.Sl.B.	Ditch
Graceville	Red River of North	1907 (About)	1922	1,020	I., Sl. B.	Ditch to Mustinka River
Grand Marais	Lake Superior	1933	1940	855	I., Cl., Sl. B.	Lake Superior
Grand Meadow	Root	1919	1939	700	I., H.T.F., F.S., Cl., Sl. B.	Root River
Granite Falls	Minnesota	1906	1935	2,388	P.S., D., T.F., F.S., Cl., Sl. B.	Minnesota River
Grove City	Crow	1923	1922	447	I., Sl. B.	North fork of Crow River
Hallock	Red River of North	1910 (About)	1904	1,353	Septic tank	South branch of Two Rivers
Hancock	Minnesota	1919	1937	827	I., T.F., F.S., Cl., Sl. B.	Ditch east of village
Harmony	Root	1923	1928	890	I., Sl. B.	Sink Hole
Hendricks	Minnesota	1917	1919	740	I., Sl. B.	Lake Hendricks
Henning	Upper Mississippi	1938	1940	948	P.S., T.F., F.S., Cl., D., Sl. B.	Ditch to Willow River
Hibbing	St. Louis	1900	1940	16,385	Com., Floc., P.S., T.F., F.S., D., Sl. B.	Hibbing Creek
Hopkins	Minnesota	1916	1917	4,100	I., Sl. B.	Nine Mile Creek
Houston	Root	1936	1937	977	Com., I., Cl., Sl. B.	Root River
Hutchinson	Crow	1902	1934	3,887	P.S., T.F., F.S., D., Sl. B.	Crow River
Ironton	Upper Mississippi	1916	1917	827	I., Sl. B.	Creek to Blackhoof Lake
Isle	Rum	1935	1937	567	P.S., D., Sl. B.	Swamp to Knife River
Janesville	Blue Earth	1916	1920	1,296	I., Sl. B.	Ditch to LeSueur River
Jordan	Minnesota	1919	1926	1,422	I., Sl. B.	Sand Creek
Kasson	Zumbro	1913	1913-41	1,230	2 I., T.F., F.S., Sl. B.	Creek to Zumbro River
Keewatin	Upper Mississippi	1914 (About)	1942	1,942	Grit, I., T.F., F.S., Cl., Sl. B.	O'Brien Creek
Kelliher	Red Lake River	1914	1914	357	I., Sl. B.	Creek
Kenyon	Zumbro	1909	1924	1,530	I., Sl. B.	North Zumbro River
Kinney	St. Louis	1920	1920	462	I., Sl. B.	Creek to McQuade River
La Crescent	Mississippi	1939	1940	815	P.S., T.F., F.S., Cl., D., Sl. B.	Mississippi River
Lake Benton	Big Sioux	1920	1920	961	I., Sl. B.	Ditch to Lake Benton
Lake City	Lower Mississippi	1921	1934	3,204	P.S., D., Cl., F.S., Sl. B.	Mississippi River

Lake Crystal	Minnesota	1916	1915	1,319	I., Sl. B.	Lily Lake
Lakefield	Des Moines	1914	1940	1,699	F. Screen, P.H.T.F., I., S., Sec. H.T.F., Sl. Chem., F.S., Cl.	Ditch to Heron Lake
Lake Park	Red River of North	1920	1939	654	I., T.F., F.S., Cl., Sl. B.	Ditch to Buffalo River
Lakeville	Lower Mississippi	1923	1935	543	I., TF., F.S., Sl. B.	Dry Run to Vermillion R.
Lancaster	Red River of North	1919	1920	475	I., Sl. B.	No. Branch of Two Rivers
Lanesboro	Root	1923	1939	1,100	P.S., T.F., F.S., Cl., D., Sl. B.	Root River
Le Center	Minnesota	1924	1924	1,232	I., Sl. B.	County Ditch
Leonidas	St. Louis			440	I., Sl. B.	Creek to St. Louis River
Lewiston	Root	After 1915	1937	761	P.S., T.F., F.S., Cl., D., Sl. B.	Dry Run
Litchfield	Crow	1912	1927	5,920	Com., P.S., T.F., F.S., Cl., D., Sl. B.	Jewett Creek
Little Fork	Rainy	1935	1939	608	I., Sl. B. *	Little Fork River
Long Prairie	Upper Mississippi	1910	1942	2,311	Com., P.S., H. T.F., F.S., Cl., Sl. Chem.	Long Prairie River
McIntosh	Red River of North	1939	1940	903	I., T.F., F.S., Cl., Sl. B.	Poplar River
McKinley	St. Louis	1920	1918	235	I., Sl. B.	Lake to Embarrass R.
Mabel	Root	1916	1916-39	741	I., H.T.F., F.S., Cl., Sl. B.	Creek to South fork of Root R.
Madison	Minnesota	1916	1916	2,312	I., Sl. B.	Ditch to Lac Qui Parle R.
Maple Lake	Crow	1914	1922	637	I., Sl. B.	Ramsey Lake
Mapleton	Blue Earth	1915	1915	1,070	I., Sl. B.	Ditch to Cobb River
Marble	Upper Mississippi	1911	1936	792	I., Sl. B.	Mud Creek to Mud Lake
Marshall	Minnesota	1904	1931	4,590	I., T.F., F.S., Cl., Sl. B.	Redwood River
Meadowlands	St. Louis		1936	142	Septic tank	Creek to Whiteface R.
Minneapolis	Upper Mississippi	1872	1938	492,370	Mpls.-St. Paul San. Dist.	Mississippi River
Mpls.-St. Paul San. District	Upper Mississippi	1938	1938		Grit, Floc., P.S., Mag.F., Cl., V.F., Inc.	Mississippi River
Montevideo	Minnesota	Before 1905	1934	5,220	Grit. P.S., T.F., F.S., D., Sl. B.	Chippewa River
Montgomery	Minnesota	1926	1927	1,741	I., Sl. B.	Ditch to Lake Pepin
Moorhead	Red River of North	1896	1935	9,491	P.S., T.F., F.S., D., Cl., Sl. B.	Red River of North
Moose Lake	St. Croix	1919	1939	1,432	P.S., D., Cl., Sl. B.	Moose River
Mora	St. Croix	1916	1940	1,494	P.S., D., Sl. B., Cl.	Snake River
Morningside	Upper Mississippi	1926	1938	1,282	Mpls. sewer system	Mississippi River
Morris	Minnesota	1907	1928	3,214	I., Sl. B.	Pomme de Terre R.
Morton	Minnesota	1937	1939	904	P.S., T.F., F.S., D., Cl., Sl. B.	Minnesota
Mountain Iron	St. Louis	1920	1920	1,492	I., Sl. B.	Creek to E. Two R.
Mountain Lake	Blue Earth	1916	1916	1,745	I., Sl. B.	Creek to Watonwan R.
New Prague	Minnesota	1923	1921	1,645	I., Sl. B.	Creek to Sand Creek
New Richland	Minnesota	1939	1940	863	Com., P.S., T.F., F.S., Cl., Sl. B. D.	Creek
New Ulm	Minnesota	1896	1940	8,743	P.S., H.T.F., F.S., Mag.,F. Cl., D., Sl. B.	Minnesota River
New York Mills	Ottertail	1935	1937	771	I., T.F., F.S., Sl. B.	Ditch to Rush Lake
Northome	Red Lake River	1915	1914	342	I., Sl. B.	Bartlett Lake
North St. Paul	Upper Mississippi	1927	1927	3,135	I., A.S., F.S., Cl., Sl. B.	Ditch to Kohlman's L.
Norwood	Minnesota	1921	1927	648	F. Screen, A.S., F.S., D., Sl. B.	Ditch to Veven's Creek

*Imhoff Tank not completed.

Appendix V—Continued

MINNESOTA DEPARTMENT OF HEALTH

Division of Water Pollution Control

Municipalities Having Sewer Systems With Sewage Treatment Plants

January 1, 1947

Location	Drainage Basin (River)	Year Const. of Municipal San. Sewer System Commenced	Year S. T. P. Constructed	Pop. (1940)	Treatment Units	Final Disposal
Olivia	Minnesota	1930	1930	1,788	I., Sl. B.	Ditch No. 61 to Minnesota R.
Ortonville	Minnesota	1912	1934	2,469	P.S., D., A.S., F.S., Sl. B.	Minnesota River
Osakis	Sauk	1918	1934-37	1,483	P.S., T.F., F.S., D., Cl., Sl. B.	Osakis Lake
Owatonna	Cannon	1916	1940	8,694	P.S., P.H.T.F., Int.S., Sec. H.T.F., F.S., Cl., D., Sl. B.	Straight River
Parkers Prairie	Upper Mississippi	1938	1940	781	I., T.F., F.S., Cl., Sl. B.	Lake Adley
Park Rapids	Upper Mississippi	1914	1930	2,643	P.S., D., Cl., Sl. B.	Fish Hook River
Paynesville	Crow	1925	1925	1,317	I., Sl. B.	Crow River
Pelican Rapids	Ottertail	1924	1936	1,560	I., T.F., F.S., Sl. B.	Pelican River
Perham	Ottertail	1927	1936	1,534	P.S., T.F., F.S., Cl., D., Sl. B.	Ottertail River
Pine City	St. Croix		1937	1,718	P.S., D., Cl., Sl. B.	Snake River
Pipestone	Big Sioux	1906	1919-27	4,682	I., T.F., F.S., Sl. B.	Creek
Plainview	Lower Mississippi	1924	1941	1,500	Grit, Com., Floc., P.S., P.H.T.F., Int.S., Sec. H.T.F., F.S., D., Sl. B.	Dry Run to Whitewater River
Princeton	Rum	1922	1930	1,865	I., Sl. B.	Rum River
Proctor	Lake Superior	1911	1940	2,468	Duluth sewer system	Lake Superior
Red Lake Falls	Red Lake	1917	1940	1,530	I., Cl., Sl. B.	Clearwater River
Redwood Falls	Minnesota	1887	1934	3,270	I., T.F., F.S., Sl. B.	Redwood River
Renville	Minnesota	1936	1936	1,265	P.S., H.T.F., F.S., D., Sl. B.	County Ditch
Riverton	Upper Mississippi			141	P.S., Sl. B.	Creek to Lake
Robbinsdale	Upper Mississippi	1939	1938	6,018	Mpls. sewer system	Mississippi River
Rochester	Zumbro	Before 1904	1926-30	26,312	P.S., F. Screen, A.S., F.S., D., Sl. B.	Zumbro River
Roseau	Red River of North	1922	1939	1,775	Com., I., Sl. B.	Roseau River
Rose Creek	Cedar	1937	1937	261	I., Cl., Sl. B.	Rose Creek
Rush City	St. Croix	1920	1926	1,020	I., Sl. B.	Rush Creek
Rushford	Root	1902	1940	1,182	Com., P.S., T.F., F.S., Cl., D., Sl. B.	Root River
Sacred Heart	Minnesota	1940	1941	752	I., T.F., F.S., Cl., Sl. B.	Ditch to Minnesota R.
St. Charles	Lower Mississippi	1922	1922	1,507	I., Sl. B.	Creek
St. James	Blue Earth	1898	1936	3,400	P.S., T.F., D., F.S., Sl. B.	Creek to North Fork
St. Louis Park	Mississippi	1930	1938	7,737	Mpls. sewer system	Mississippi River

St. Paul	Upper Mississippi	1872	1938	287,756	Mpls.-St. Paul San. Dist.	Mississippi River
Sauk Center	Upper Mississippi	1901	1934	3,016	I., T.F., F.S., Sl. B.	Sauk River
Savage	Minnesota		1939	222	I., T.F., F.S. Sl. B.	Creek to Minn. River
Scanlon	St. Louis	1941	1941	460	I., Sl. B.	St. Louis River
Sherburne	Blue Earth	1906	1917	1,030	I., Sl. B.	County Ditch to Creek to Tuttle Lake
Slayton	Des Moines	1902	1931	1,587	I., Sl. B.	Beaver Creek
Sleepy Eye	Minnesota	1914	1914	2,923	I., Sl. B.	Sleepy Eye Creek
South St. Paul	Lower Mississippi	1919	1940	11,844	Com., Grit, Grease Flt., Floc., P.S., T.F., F.S., Cl., Sl. Lagoon	Mississippi River
Springfield	Minnesota	1914	1939	2,361	Com., P.S., T.F., F.S., Cl., D., Sl. B.	Cottonwood River
Spring Grove	Lower Mississippi	1930	1930	967	I., Sl. B.	Creek South of Town
Spring Valley	Root	1917	1938	2,133	P.S., T.F., F.S., Cl., Sl. B.	Spring Valley Creek
Staples	Upper Mississippi	1908 (About)	1917-32	2,952	I., T.F., F.S., Sl. B.	Hayden Creek
Starbuck	Chippewa	1929	1929	972	I., Sl. B.	Creek through Lake to Chippewa River
Stephen	Red River of North	1920	1941	673	I., Sl. B.	Tamarac River
Stewartville	Root	1939	1940	1,025	P.S., T.F., F.S., Cl., D., Sl. B.	Root River
Taconite	Upper Mississippi	1918	1919	375	I., Sl. B.	Ditch to Swan River
Taylors Falls	St. Croix	After 1923	1941	552	P.S., T.F., F.S., Cl., D., Sl. B.	St. Croix River
Thief River Falls	Red Lake	1908	1939	6,019	Com., P.S., T.F., F.S., Cl., D., Sl. B.	Red Lake River
Tower	Rainy	1937	1937	820	I., Sl. B.	East Branch of Two R.
Tracy	Minnesota	1909	1923-38	3,085	I., T.F., F.S., Sl. B.	Creek to Cottonwood R.
Virginia	St. Louis	About 1907	1914	12,264	I., T.F., F.S., Sl. B.	Three Mile Lake
Wabasha	Lower Mississippi	1916	1934	2,368	P.S., F.S., D., Sl. B.	Mississippi River
Wabasso	Minnesota	1920	1920	604	I., Sl. B.	Ditch Northeast of village
Waconia	Minnesota	1924	1924	1,315	I., T.F., F.S., Cl., Sl. B.	Waconia Lake
Wadena	Upper Mississippi	1912	1916-33	2,916	I., T.F., F.S., Sl. B.	Union Creek
Waite Park	Upper Mississippi	1926	1928	1,427	I., Cl., Sl. B.	Sauk River
Walker	Upper Mississippi	1935	1936	939	P.S., T.F., Cl., Sl. B., D.	Leech Lake
Walnut Grove	Minnesota	1919	1919	753	I., Sl. B.	County Ditch to Creek to Cottonwood River
Warren	Red River of North	1908	1914	1,639	I., Sl. B.	Snake River
Warroad	Rainy	1914	1937	1,309	I., Cl., Sl. B.	Warroad River
Watertown	Crow		1934	737	I., Sl. B.	Crow River
Waverly	Crow	1926	1926	458	I., Cl., Sl. B.	Lake Waverly
Wayzata	Upper Mississippi	1939	1940	1,473	Com., P.S., T.F., F.S., S.F., Cl., Sl. B., Glass Covered, D.	Lake Minnetonka
Wells	Blue Earth	1899	1920	2,217	I., Sl. B.	Ditch to Maple River
Westbrook	Minnesota	1922	1922	871	I., Sl. B.	Ditch to Highwater Creek
West Concord	Zumbro	1926	1927	744	P.S., A.S., F.S., D., Sl. B.	Creek to Zumbro River
West St. Paul	Upper Mississippi	1921	1938	5,733	St. Paul sewer system	Mississippi River
White Bear	Upper Mississippi	1926	1927	2,858	F. Screen, A.S., F.S., D., Sl. B.	Goose Lake
Willmar	Crow	1912	1931	7,623	P.S., T.F., F.S., D., Sl. B.	Ditch to South Fork of Crow R.
Winona	Lower Mississippi	1892	1935	22,490	P.S., Cl., D., Sl. B.	Mississippi River
Wolverton	Red River of North	1918	1917	222	I., Sl. B.	Ravine to Red River
Worthington	Des Moines	1905	1916-32	5,918	P.S., T.F., F.S., D., Sl. B.	County Ditch

KEY

A.S.—Activated Sludge—Mechanical Aeration

Cl.—Chlorination

Com.—Comminutor

D.—Digester

Floc.—Floculation Tank

F.S.—Final Settling Tank

F. Screens—Fine Screens

Grease Flt.—Grease Flotation by means of air

Grit—Grit Chamber

H.T.F.—High Rate Trickling Filter

I.—Imhoff Tank

Inc.—Incinerator for Sludge Conditioning

Int. S.—Intermediate Settling Tank

Mag. F.—Magnetite Filter

P.—Primary

P.S.—Primary Settling Tank

S.F.—Sand Filter

Sec.—Secondary

Sl. B.—Open Sludge Bed

Sl. Chem.—Chemical Treatment of Sludge, and Subsequent Draining on Sand Filters

T.F.—Low Rate Trickling Filter

V.F.—Drum Type Vacuum Filter for Sludge Dewatering

Appendix VI

References

More detailed information on the care and operation of sewage treatment plants may be obtained from the following publications.

A. Books

"Standard Methods of Water and Sewage Analysis," American Public Health Association

"Sewage Treatment," Imhoff and Fair

"Sewerage and Sewage Treatment," Hardenbergh

"Sewage Treatment Works," Kiefer

"Sewerage and Sewage Treatment," Babbit

B. Magazines and Bulletins

Manual of Practice No. 1, "Occupational Hazards in Operation of Sewage Works," Federation of Sewage Works Association

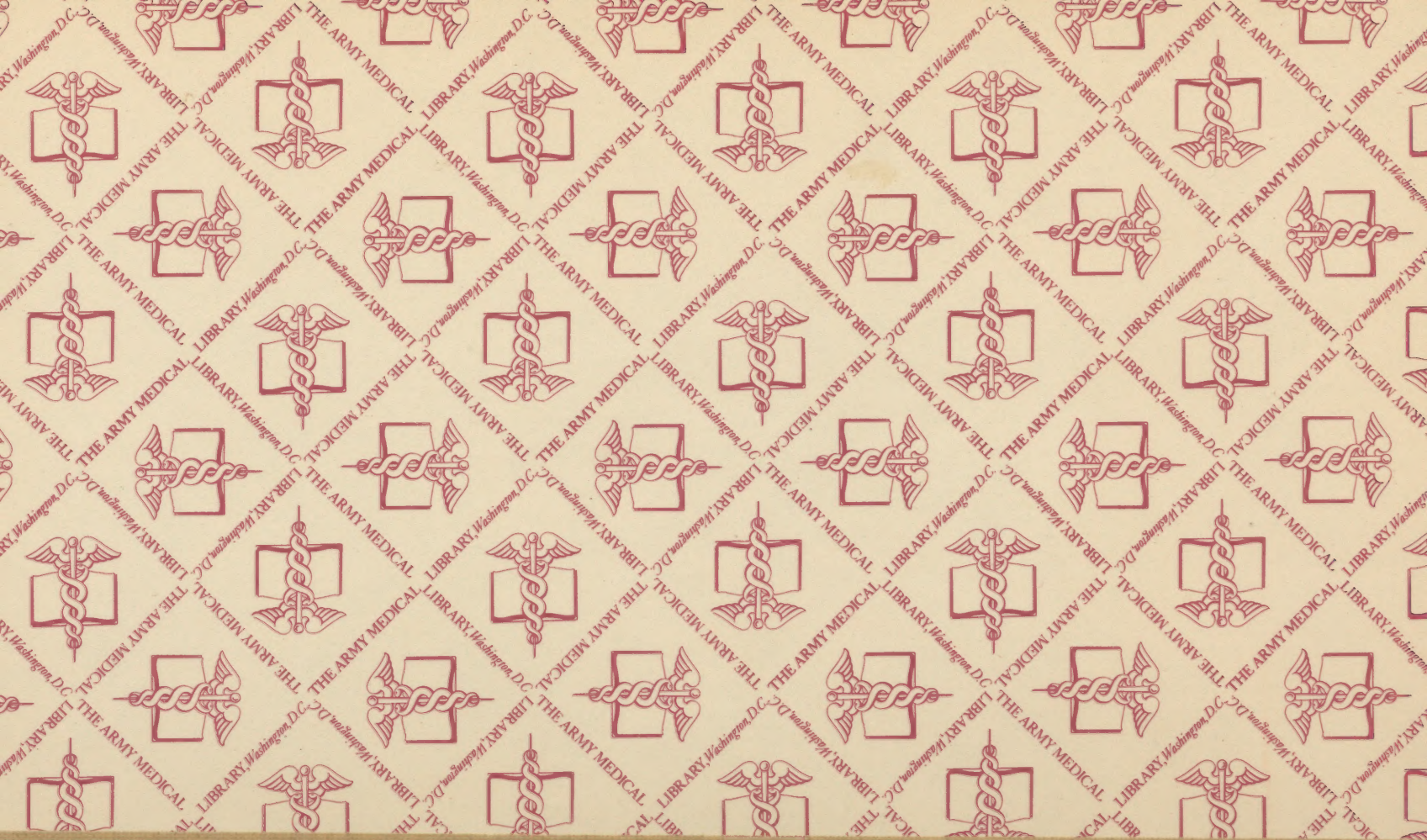
Manual of Practice No. 2, "Utilization of Sewage Sludge as Fertilizer," Federation of Sewage Works Association

"Sewage Works Engineering," 24 West 40th Street, New York 18, N. Y.

"Sewage Works Journal," Federation of Sewage Works Association, 325 Illinois Building, Champaign, Illinois

"Water Works and Sewerage," Gillet Publishing Company, 330 South Wells Street, Chicago, Illinois

"Public Works," 310 East 45th Street, New York, N. Y.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